SAE journal

IN THIS ISSUE . . .

GAS TURBINES for automobiles have thermodynamic stumbling blocks 18

FAIL SAFE vs SAFE LIFE methods of aircraft design 26

HIGH SPEED, light weight V diesels 30

POWER PACKAGE for the Lockheed Electra 50

FUELS for turbine transports 55

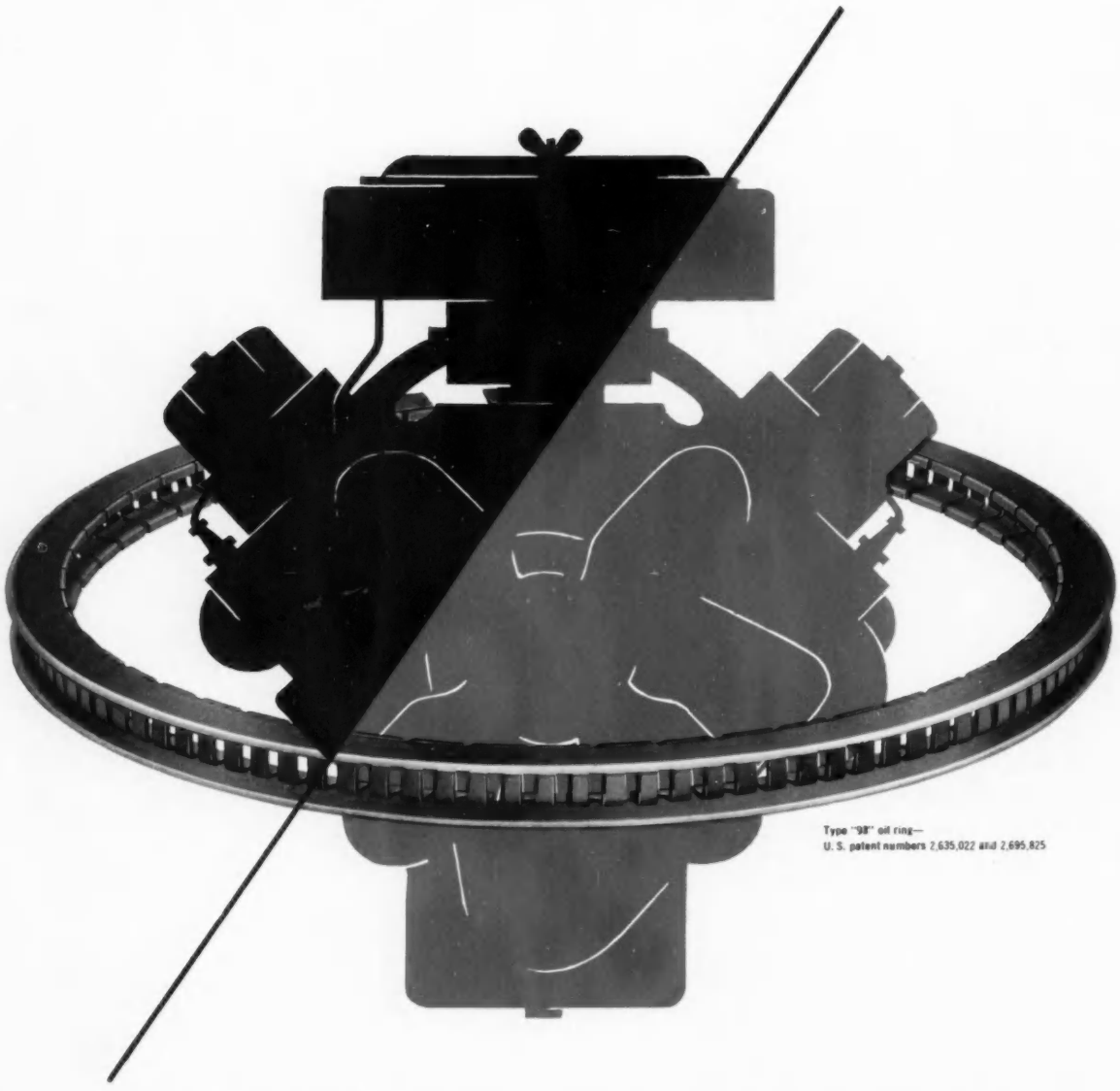
FULL DETAILS on GM's new Free Piston engine 60

Table of contents on page 15

JUNE 1956

Published by The Society of Automotive Engineers

More than half*...



Type "98" oil ring—
U. S. patent numbers 2,635,022 and 2,695,825

Of the 10,329,578 passenger car engines produced in the U.S. from January 1, 1955 through May 5, 1956 were equipped with

PERFECT CIRCLE

type "98"
chrome oil rings

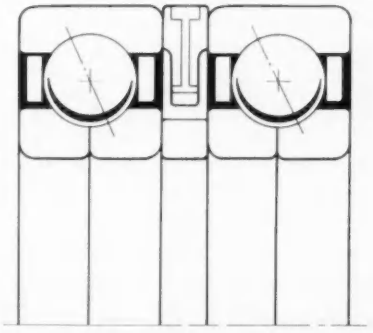
*52.1% were Perfect Circle Type "98" chrome oil rings. 47.9% were all other oil ring types combined, including other Perfect Circle oil ring types.

FACTS

about

NEW DEPARTURE

BALL BEARINGS FOR JET ENGINES



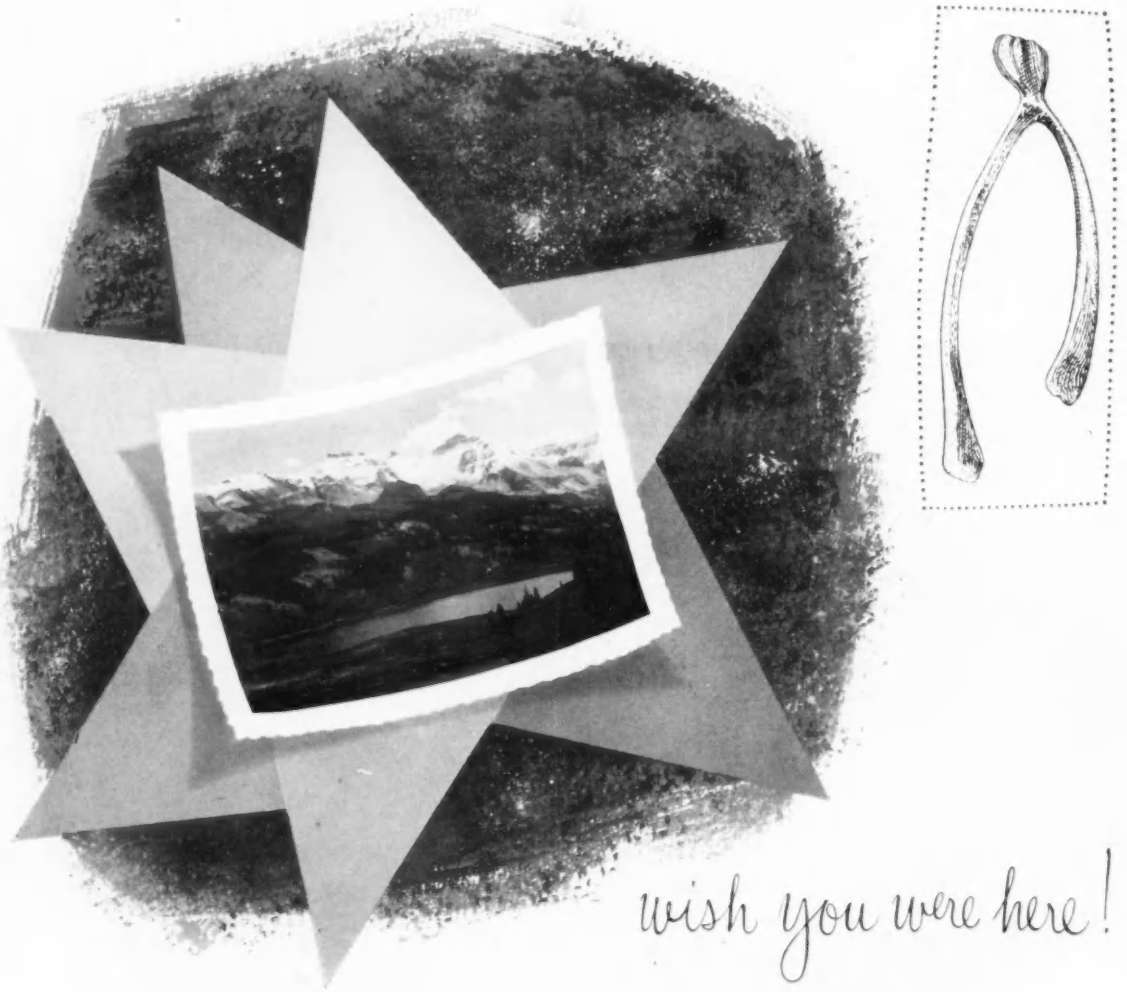
Matched sets of New Departure split inner ring bearings are made with great accuracy to assure equal distribution of the heavy thrust loads developed by modern aircraft engines.

New Departure is bringing to bear the most extensive facilities in the industry for the research, development, testing and production of ball bearings for jet and turboprop engines . . . bearings made of heat-stabilized ball bearing steel and special high-temperature alloys for maximum service at elevated temperatures and high speeds . . . ball bearings designed to operate under adverse conditions of lubrication . . . bearings fully capable of taking the heavy thrust loads existing in high-performance jet and turboprop engines.

Indication of New Departure's knowledge and experience in the production of the specialized bearings required for modern aircraft performance is the split inner ring types shown above, being made for all the major jet engine manufacturers in America.

Write for Turbine Bearing folder TB

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.



The USAF Inter Continental Ballistics Missiles are being developed in the heart of the Rocky Mountain Empire by the foremost scientists and engineers in America, the research team of The Glenn L. Martin Co., Denver Div.

. . . and you are invited to become a part of this team that has produced so many other Martin "firsts" in research engineering and development of weapon systems.

The job is a challenging one. Furthermore, it is permanent. And Martin is providing the finest engineering, laboratory and production facilities available. Salary levels, of course, are commensurate with experience and ability.

But the really wonderful advantage that engineers have at Martin's Denver Division is that of rapidly advancing oneself professionally while enjoying one of the most beautiful and stimulating environments in the world . . . Colorful Colorado.

Here's what you'll find: Brilliant sunshine over 300 days each year; unlimited recreational facilities in winter as well as summer; healthy, mountain air that's crisp, fresh and exhilarating; cool summers, mild winters, modern schools and shopping centers, and relaxed living for every member of the family.

Martin is developing another "first" in Denver. So why not take your vacation in Colorado, and while you're enjoying the beauty of the Rockies, take time to stop in and talk to the people at Martin. It might be a turning point in your life and you'll wish you were here too . . . PERMANENTLY.

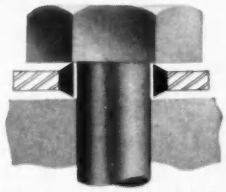
Martin extends this invitation to Aeronautical, Mechanical, Electrical, and Structural Engineers and Technicians and to Mathematicians and Physicists. If you have already made other vacation plans however...

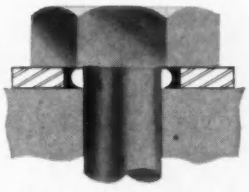
Write to:
Emmett E. Hearn, Employment Dir., Dept. E-4, P.O. Box 179, Denver 1, Colo.

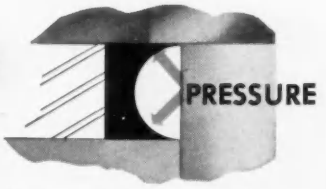
MARTIN
DENVER DIVISION

SAE JOURNAL, June, 1956, Vol. 64, No. 7. Published monthly except two issues in January by the Society of Automotive Engineers, Inc. Publication office, at 10 McGovern Ave., Lancaster, Pa. Editorial and advertising department at the headquarters of the Society, 29 West 39th Street, New York 18, N. Y. $1 per number; $10 per year; foreign $12 per year; to members 50 cents per number, $5 per year. Entered as second class matter, September 15, 1948, at the Post Office at Lancaster, Pa., under the act of August 24, 1912. Acceptance for mailing at special rate of postage provided for in the Act of February 28, 1925, embodied in paragraph (d-2), Sec. 34.40, P. L. and R., of 1948. Additional entry at New York, N. Y.

Leak-proof Precision Dyna-seals
solve countless sealing problems


Dyna-seal before bolt head is drawn down


Bolt head drawn down —with pressure applied



How pressure forces sealing lips against surfaces

Vibration Proof, Lock Washer Action

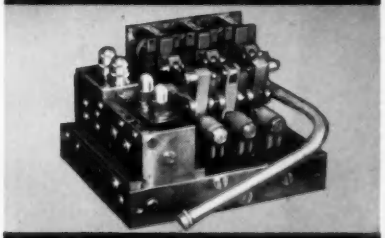
Dyna-seals bring to an end an age-old leakage problem on face-to-face connections. They provide a positive and economical liquid or vapor seal against a steady or pulsating pressure of up to 10,000 P.S.I.

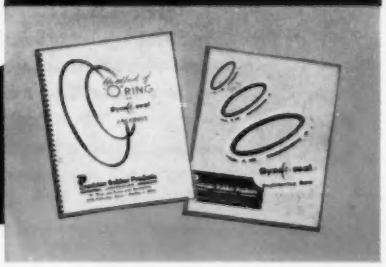
The practical Precision Dyna-seal is an easy-to-handle one piece unit, consisting of a flared rubber sealing ring, heat and pressure bonded to a steel washer. No grooves or special machining required. Permanent, leak-proof sealing without excess stress. (Bolting torque is reduced.) Simplicity of the Precision Dyna-seal greatly reduces tooling and assembly costs.

Dyna-seals give exacting performance under bolt and rivet heads, cap nuts, flanges or special fittings. Let a Precision engineer demonstrate the Dyna-seal cost and labor saving advantages to you. Write today!

Typical Dyna-seal Applications

Dyna-seals provide uncompromising sealing performance under bolt heads of the nuclear submarine Seawolf periscope mounting.


30 Dyna-seals solve plug-leakage problem on The NATCO Hydraulic Control Unit manifold.



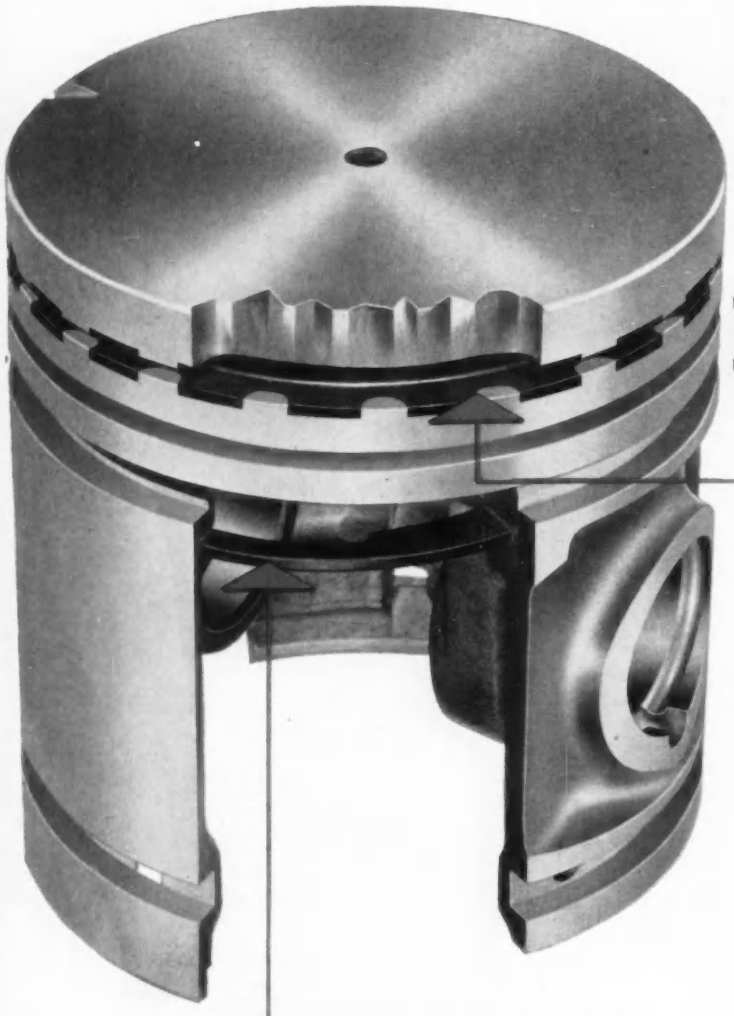
Write for your free copy of the Precision catalog on Dyna-seals.

Precision Rubber Products Corporation • "O" Ring and Dyna-seal Specialists

3110 Oakridge Drive, Dayton 7, Ohio

Canadian Plant at: Ste. Thérèse de Blainville, Québec

NOW! STERLING CONFORMATIC* PISTONS



CONFORMATIC STEEL CONTROL MEMBER, anchored at the pin bosses only, controls skirt clearance . . . hot or cold! The metered steel insert allows you to specify the piston clearance you want for your engine. (Clearances from zero to ½ thousandth inch are generally recommended.)

are available with LOW COST Intra-Cast* STEEL-LINED GROOVES

***Steel protection—top and bottom*—gives sensationally longer life to rings and grooves.**

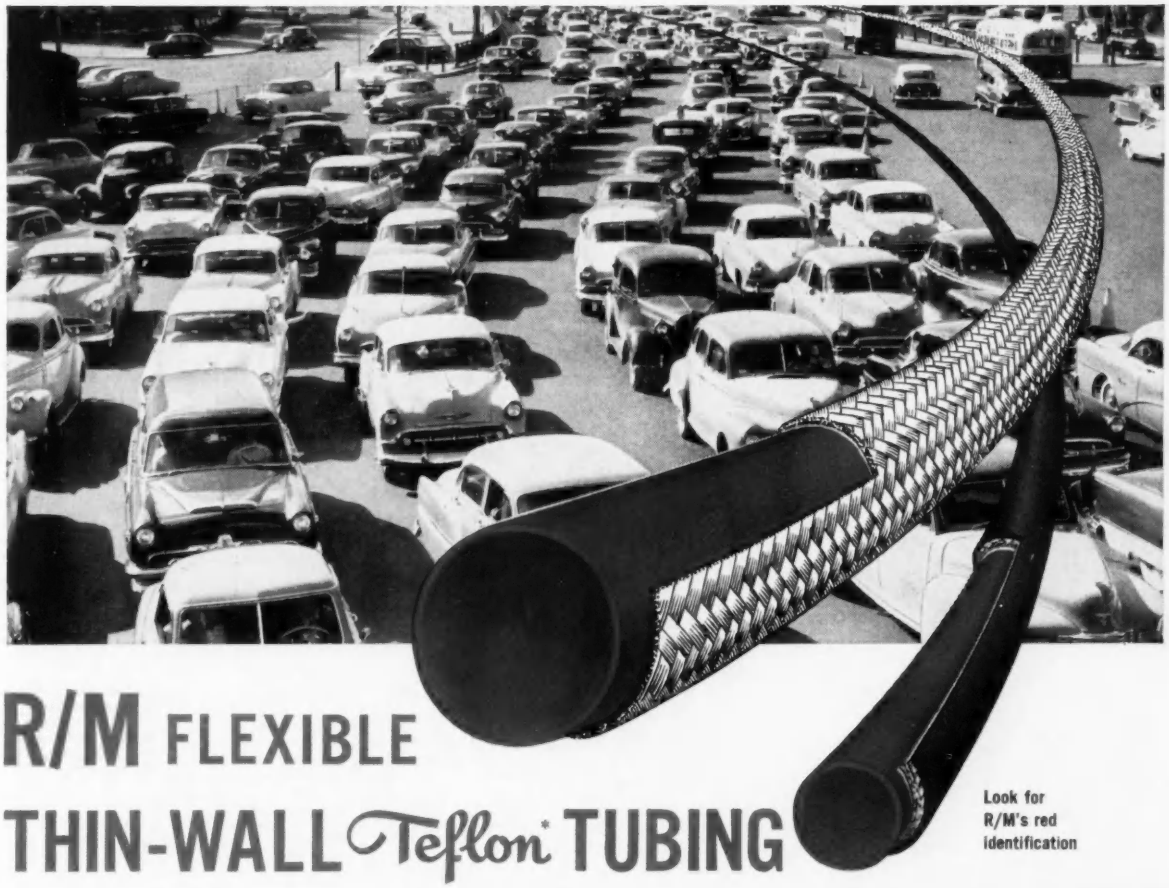
This ring is *integrally cast* into the piston . . . positioned so that when the grooves are machined, the top ring groove is *lined with steel* and has islands of aluminum for ring cooling. This Intra-Cast steel-protected groove resists enlargement and materially reduces top ring land wear and rounding. And, it does it at far less cost than other methods.

** Tradename Registered*

STERLING ALUMINUM PRODUCTS INC.

ST. LOUIS, MISSOURI

NOW AVAILABLE for automotive applications



R/M FLEXIBLE THIN-WALL Teflon* TUBING

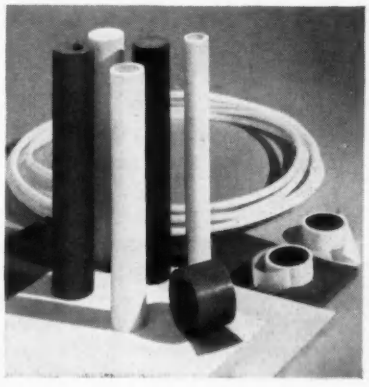
Look for R/M's red identification

Working with "Teflon" requires knowledge and skills that only experience can provide. Raybestos-Manhattan's research and testing laboratories have been actively engaged in developing the vast potentials of this remarkable material ever since it first became available.

Now, out of these laboratories comes R/M Flexible Thin-Wall "Teflon" Tubing—stainless steel wire braided or rubber covered—for automotive applications, particularly the cooling of oil in automatic transmissions. This new tubing has great flexibility and does not expand, contract or fatigue. It also has great resistance to high temperatures and corrosive lubricants. Available through leading coupling manufacturers. List of suppliers and complete specifications furnished on request.

Other R/M "Teflon" products for the automotive industry include rods, sheets, tubes and tape; centerless ground rods held to very close tolerances; stress-relieved molded rods and tubes; Raylon —a mechanical grade of "Teflon" with many of the characteristics and properties of virgin "Teflon." *For details, call or write R/M.*

*Du Pont trademark



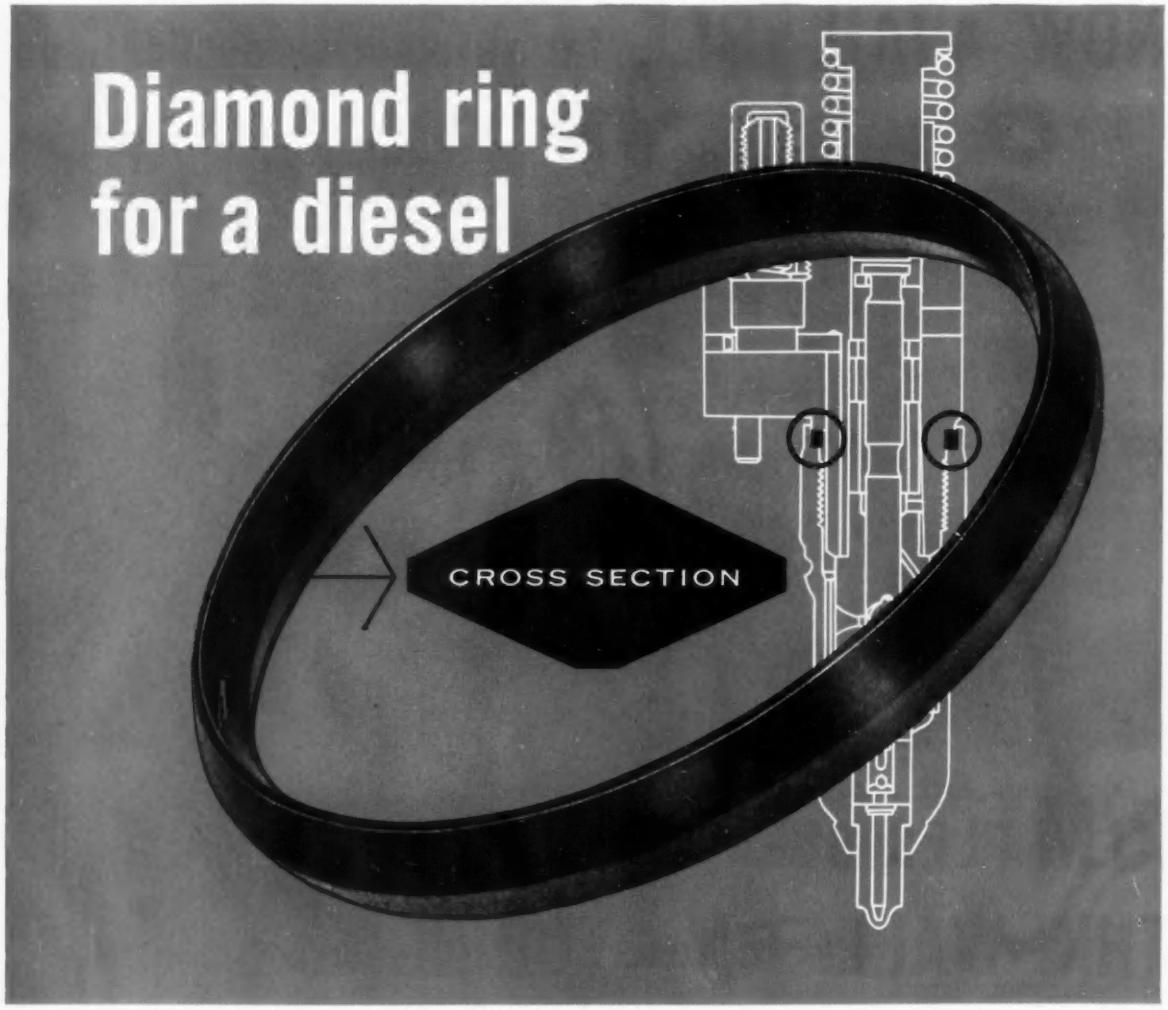
RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION, MANHEIM, PA.

FACTORIES: Bridgeport, Conn.; Manheim, Pa.; No. Charleston, S.C.; Passaic, N.J.; Neenah, Wis.; Crawfordsville, Ind.; Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Engineered Plastic, Industrial Rubber, and Sintered Metal Products • Packings • Asbestos Textiles • Abrasive and Diamond Wheels Rubber Covered Equipment • Brake Linings • Brake Blocks • Clutch Facings • Fan Belts • Radiator Hose • Laundry Pads and Covers • Bowling Balls

Diamond ring for a diesel



ELIMINATES INJECTION NOZZLE LEAKS

Crankcase dilution can be a big headache. But not for one of the leading Diesel manufacturers. They knew that the right injection nozzle seal would cure a major cause . . . and came to C/R Sirvene engineers for help. C/R manufactured this Sirvene (synthetic rubber) part to extremely critical dimensions and physical properties to match the equally precise dimensions of the assembly. Result: no more leakage. When you need a pliable mechanical part compounded to meet critical specifications of heat, pressure, abrasion resistance and molded to the most exacting tolerances, you need C/R Sirvene. C/R Sirvene engineers will gladly cooperate with you in all phases of your sealing problem . . . from design, compounding of the correct oil-resistant elastomers, through laboratory-like control of production quantities. Write for your copy of the new booklet, "Sirvene."

CHICAGO RAWHIDE MANUFACTURING COMPANY
1243 Elston Avenue, Chicago 22, Illinois

Offices in 55 principal cities • See your telephone book

In Canada: Manufactured and Distributed by
Super Oil Seal Mfg. Co., Ltd., Hamilton, Ontario

Export Sales: Geon International Corp., Great Neck, New York

SIRVENE C/R DIVISION
CHICAGO RAWHIDE

Other C/R Products
C/R Shaft and End Face Seals • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears

Make in the U.K. and sell to new markets

The E.N.V. organisation of London, England, invites the collaboration of an American manufacturer seeking new markets in Britain, Europe and the British Commonwealth.

World famous for spiral bevel gears, hypoid drives and associated transmission components, E.N.V. has two modern plants, covering over 250,000 sq. ft. and employing more than 1600 operators.

If you have a suitable product and wish to avail yourself of manufacturing resources enabling you to expand in the vast Sterling area, E.N.V. will be glad to tell you more about this unusual opportunity.

ENV

E.N.V. ENGINEERING COMPANY LIMITED

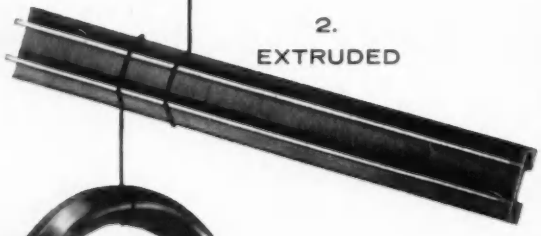
HYTHE ROAD WILLESDEN LONDON N.W.10 ENGLAND

AP 265/46

ACADIA

MEETS YOUR SYNTHETIC RUBBER NEEDS

BEST OUT OF 3 WAYS!



And when there's another way to form synthetic rubber, you can be sure it will be available from Acadia!

Right now Acadia is precisely meeting all manner of rubber specifications. Very often Acadia helps users to find a better, less costly way.

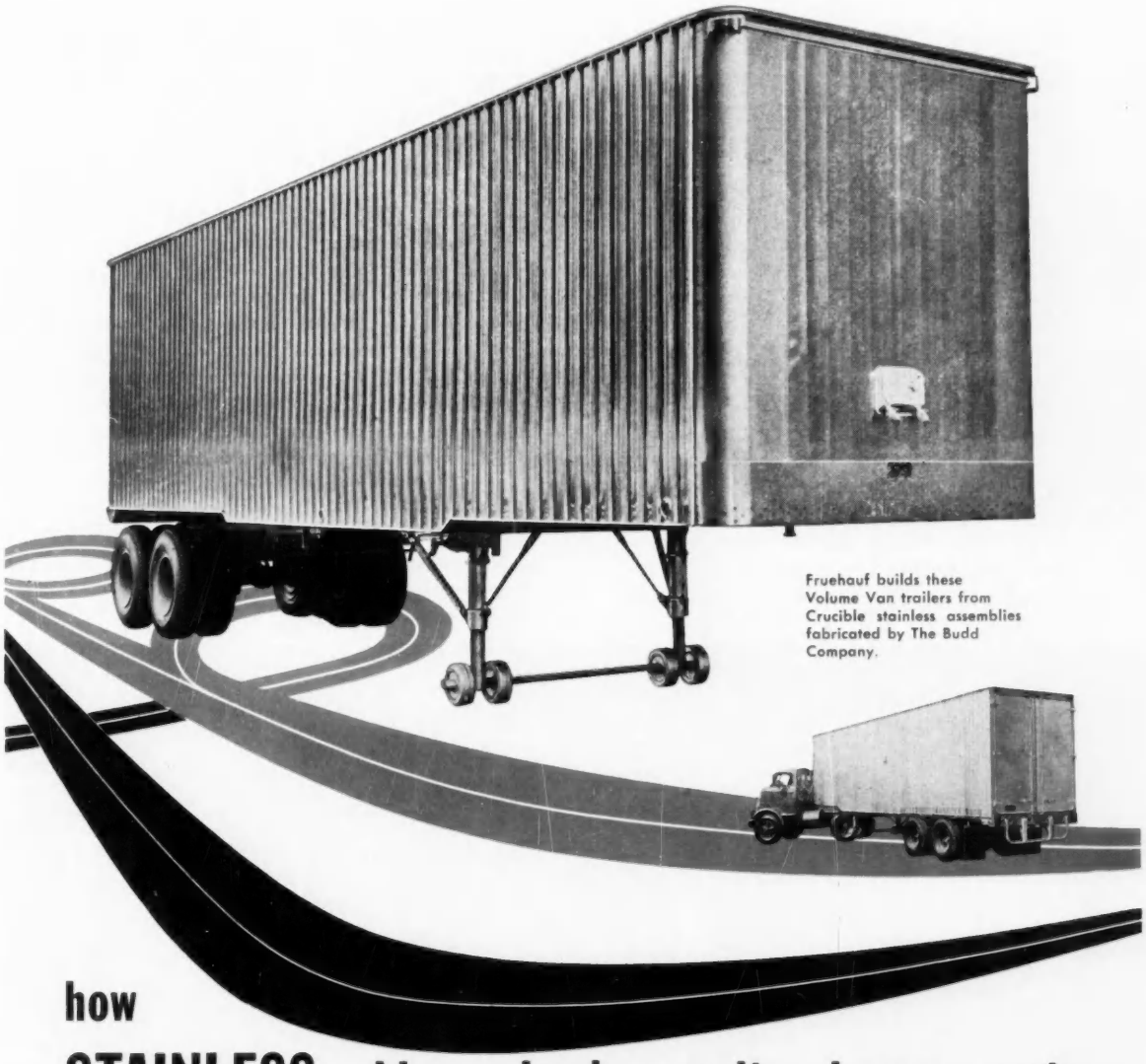
For in addition to the complete choice of shape, size or method, Acadia offers its wide experience in developing special rubber properties. Here you get exactly the characteristics you want—*strength, compression-deflection, resistance to oil, age or what have you*. Here, too, is the remarkable Acadia SILICONE rubber that stays resilient at 100° *below zero*, or 500° above. It's available molded or extruded for gaskets, seals, "O" rings, washers, sheets, cut-parts and packings.

Would you like further information about Acadia synthetics for *your* product? A letter or postcard will bring an Acadia representative at your convenience.

ACADIA *Synthetic* PRODUCTS

DIVISION OF WESTERN FELT WORKS
4021-4139 West Ogden Avenue, Chicago 23, Illinois
Branch Offices in Principal Cities

MANUFACTURERS AND CUTTERS OF WOOL FELT



Fruehauf builds these Volume Van trailers from Crucible stainless assemblies fabricated by The Budd Company.

how STAINLESS adds payload capacity—lowers costs

Cargo capacity and profits go hand-in-hand in the transportation field. And stainless steel's high-strength gives this Fruehauf *Volume Van* trailer construction advantages that add up to carrying capacity above that of other van type trailers.

Stainless steel provides extreme rigidity and toughness, yet reduces dimensions of side walls, roof tension sheets, and front and rear panels. As Fruehauf says:

"Not only is there a gain in cubic capacity as well as strength, but an actual saving in weight so that the net result of the complete design is a transportation unit which will provide the highest possible return on the initial investment."

And stainless lasts indefinitely. In fact, there's a tradition in the industry that "no stainless steel trailer has ever worn out." For stainless resists wear, fights corrosion, takes a lot of punishment before it will scratch or dent. Maintenance is greatly reduced.

Should your product use stainless? It may be the answer to greater efficiency, lower costs, a more attractive product for you, too. Ask your local Crucible representative, or write *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor — Railway & Power Engineering Corp., Ltd.

Imagineering the 195X models . . . in Alcoa® Aluminum

New Aluminum rocker arm makes engines breathe easier

Here's a good example of scientific snowballing for you. As engines get bigger and faster, valve size and speed also increase. But F= ma; so to accelerate the larger valves faster, disproportionately *larger* valve train parts are required. Soon valve spring design loads get so large that resonance and spring surge become a problem.

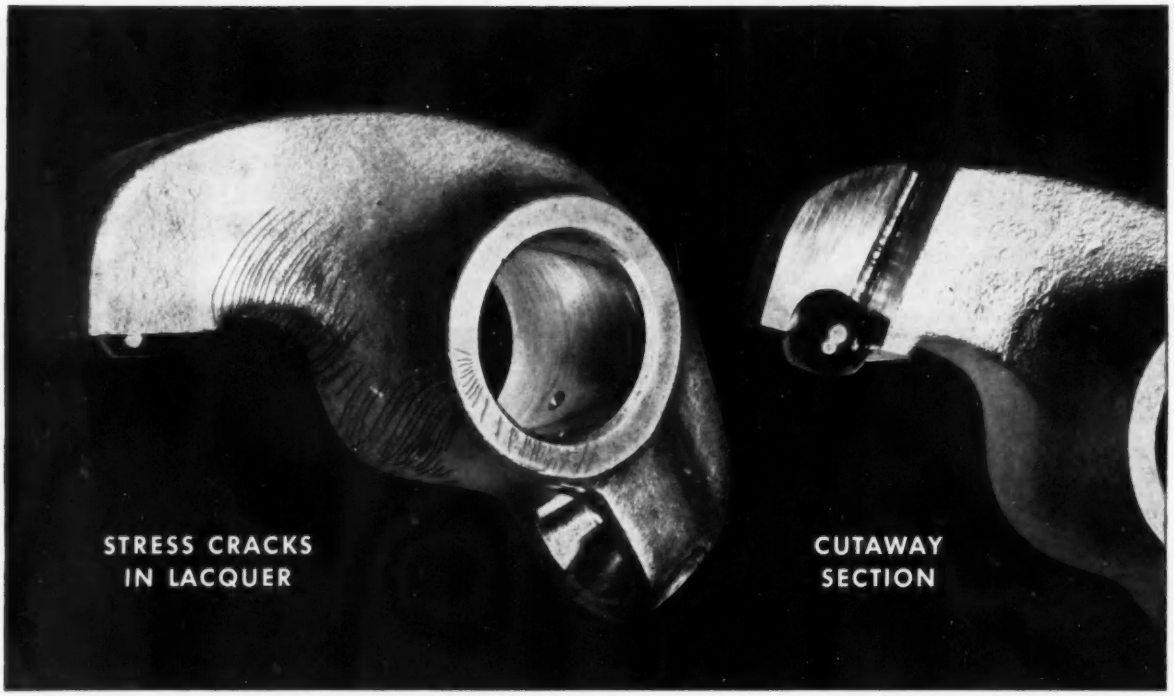
To alleviate the problem, Alcoa has designed a new aluminum rocker arm which weighs about 33% less than malleable iron rocker arms. It reduces the accelerating forces required, permits a less stiff valve spring, and literally makes engines breathe easier.

Furthermore, we can die cast these rocker arms to accurate tolerances and they'll require less machining than the malleable arms.

An interesting feature of the rocker arm is the method of contacting the valve stem—a flattened steel ball fitted into a die-cast recess of the rocker arm. The ball freely articulates in this socket and perfect alignment is secured with the end of the valve stem. See cutaway in photo below.

Stress distribution in the new arm was studied by the brittle lacquer method. Then, following a deflection determination, the arms were tested in actual engine operation. The performance has been excellent, and we would now like to work with you to develop rocker arms for your particular engines.

Every year the amount of aluminum per automobile goes up as imaginative engineers make more parts cheaper or lighter. Our Development Division has unmatched facilities to help you imagineer your 195X (or '6X!) models . . . in Alcoa Aluminum. Aluminum Company of America, 1844-F Alcoa Building, Pittsburgh 19, Pennsylvania.



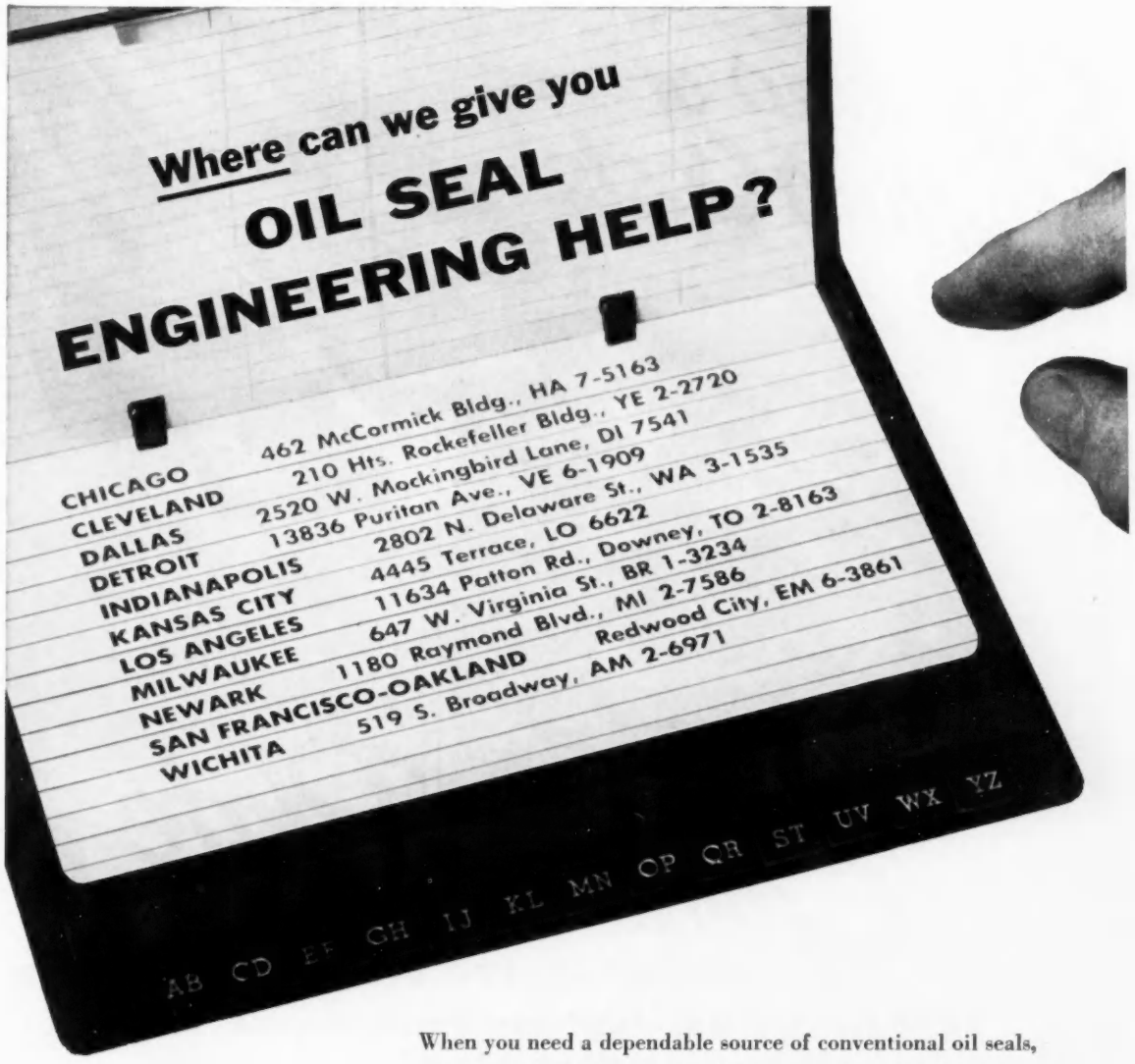
Aluminum rocker arms were coated with brittle lacquer and put under load. Crack lines in lacquer show areas of high stress. This is a valuable design tool which helps engineers eliminate points of possible weakness. It is one more of the many facilities available at our superbly equipped Development Division to help you imagineer more new parts from Alcoa Aluminum.

Your Guide to the Best in Aluminum Value

WE CHOSE ALCOA ALUMINUM MILL PRODUCTS
ALUMINUM COMPANY OF AMERICA
©ACOA

THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

Always Fasten Aluminum With Alcoa Aluminum Fasteners


Where can we give you
OIL SEAL
ENGINEERING HELP?
CHICAGO 462 McCormick Bldg., HA 7-5163
CLEVELAND 210 Hts. Rockefeller Bldg., YE 2-2720
DALLAS 2520 W. Mockingbird Lane, DI 7541
DETROIT 13836 Puritan Ave., VE 6-1909
INDIANAPOLIS 2802 N. Delaware St., WA 3-1535
KANSAS CITY 4445 Terrace, LO 6622
LOS ANGELES 11634 Patton Rd., Downey, TO 2-8163
MILWAUKEE 647 W. Virginia St., BR 1-3234
NEWARK 1180 Raymond Blvd., MI 2-7586
SAN FRANCISCO-OAKLAND Redwood City, EM 6-3861
WICHITA 519 S. Broadway, AM 2-6971
AB CD EF GH IJ KL MN OP QR ST UV WX YZ

When you need a dependable source of conventional oil seals, or engineering help on new seals to meet unique conditions, call your National Oil Seal Applications Engineer. He's a specialist in seals, factory trained and a veteran at his business. Whether your seals can be shipped from stock, made from existing tools, or require new engineering, he'll give you a fast, accurate and realistic answer.

Your National Applications Engineer is backed by the productive capability of four big NMB plants, and 35 years of oil seal specialization. Call him while your new design is still on the drafting board—the best time to specify seals. His telephone number and address are listed above.

NATIONAL
OIL & GREASE SEALS
O-RINGS SHIMS
Product of the world's largest exclusive manufacturer of oil seals

NATIONAL MOTOR BEARING CO., INC.
Plants at Van Wert, Ohio, Redwood City, Downey and Long Beach, Calif.
General Offices: Redwood City

3675

Speaking of Cutting Costs

General Plate

COMPOSITE METAL CONTACTS

Save Money and Improve Performance, too!

That's right — time and time again General Plate Division has been able to cut electrical contact costs for customers — while improving product performance.

At General Plate Division customers with contact questions deal directly with a top notch team of Engineers, Production people, and Cost Analysts who specialize in contact activities.

Result? Savings — savings by design for alert customers — with improved performance in the bargain.

Here's what's behind it —

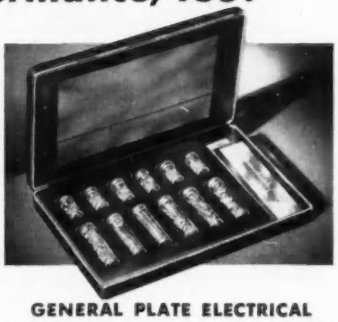
Drawing on forty years of metal cladding experience, General Plate Engineers have developed superior bonded metals which combine the best electrical and mechanical properties of two or more separate metals for greatest contact efficiency and economy.

General Plate Production people have developed the finest facilities available for the manufacture of all kinds of contacts from these materials.

General Plate Application Engineers and Cost Analysts have worked out contact design details which assure you contacts you can count on — at real savings.

You too can earn this double dividend at General Plate Division — why not investigate — today.

METALS & CONTROLS CORPORATION
GENERAL PLATE DIVISION
116 FOREST STREET, ATTLEBORO, MASS.



GENERAL PLATE ELECTRICAL CONTACT KIT FOR LABORATORY AND DEVELOPMENT USE

Kit K11 contains a wide assortment of silver rivet contacts; Kit K12 has representative standard button contacts. Also included are metal strips for fabrication of contact parts. These kits are available at nominal cost. Bulletin available.

You can profit by using General Plate Composite Metals

For the Sake of Argument

Procedures and Principles . . .

By Norman G. Shidle

Most people get where they're going fastest if they start with a road map in hand . . . but not everybody.

Detailed procedures on how to do a job are necessary insurance in most cases. Without them, supervision can't be sure of satisfactory average performance. But, when forced onto certain types of person, they insure that the performance will be no more than satisfactory. Rigorously applied, procedures become rules . . . and rules are things to be followed.

The man who intuitively looks for new and better ways is sometimes kept from maximum performance when started off with too detailed procedures.

Rogers, Slade & Hill's "Management Briefs" told recently of a nationally successful company in a service industry which got to leadership without standards of operation set forth in terms of procedures.

Instead of the procedures common to its competitors, this company has basic principles . . . which it refers to as "beliefs".

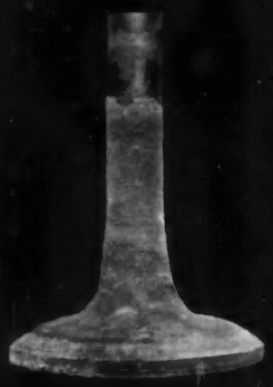
"Most of these," the story goes, "are unwritten, but they are thoroughly understood. They define the objectives of the business, the criteria of its operations, its basic interpretation of the Facts of Life in its field, the general structure of its plan—and very little else.

"If a man understands and believes in these things, he can be counted on to operate within the framework they establish. And experience has shown that anything he does within the framework—on his own initiative, ingenuity, and resourcefulness—is almost certainly as consistent with the firm's practice as though it had been elaborately specified . . . not to mention being usually better suited to the individual requirements of the customer, and often a good deal more vigorous and dynamic than a prescribed action."

One reason more companies don't go this route, probably, is the much greater difficulty of communicating "beliefs" in terms applicable by the individual to his daily problems. This method transfers much responsibility from the supervisor to the doer.

Some folks do better with procedures than with beliefs: . . . and some do vice versa.

Performance Records Prove Eaton Free-Valves DO Last Longer!



CONVENTIONAL VALVES

Failure unpredictable—anywhere between 5,000 and 40,000 miles. Impossible to set up dependable preventative maintenance schedule.

EATON FREE-VALVES

Still in good condition after 100,000 or more miles, permitting preventative maintenance scheduling. No in-between servicing necessary.

The Eaton Free-Valve is free of any restraining force set up by the valve spring. The normal creeping tendency of the valve causes it to take infinitely variable positions with respect to the seat at successive lift cycles.

The common goal of valve and engine manufacturers—and truck operators—is to obtain valve life equal to that of other major components, thereby eliminating the necessity for valve servicing between major overhauls. Performance records covering millions of miles of heavy-duty operation prove that Eaton Free-Valves have achieved this goal.

Eaton Free-Valves are genuinely "free"—free to turn at random in either direction, during a major portion of the lift-cycle. This free-floating action wipes stem and seat free of deposits; keeps a film of oil on stem and guide surfaces. Scuffing is prevented, wear is reduced. Hot-spots due to local leakage are eliminated. Longer valve life is a natural result.

Our engineers will be glad to explain how Eaton Free-Valves can be applied to engines of all types and sizes.

EATON

VALVE DIVISION
MANUFACTURING COMPANY
9771 FRENCH ROAD • DETROIT 13, MICHIGAN

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

SAE Journal

Norman G. Shidle
Editor

Frances L. Weeden
Managing Editor

SAE JOURNAL PUBLICATION OFFICE
Business Press, Inc.
10 McGovern Ave.
Lancaster, Pa.

EDITORIAL OFFICE
29 West 39 St.
New York 18, N. Y.
Tel.: LOngacre 5-7174

ADVERTISING OFFICES
E. D. Boyer
Eastern Advertising Manager
29 West 39 Street
New York 18, N. Y.
Tel.: LOngacre 5-7170

W. W. Milne
Western Advertising Manager
7530 Sheridan Road
Chicago 26, Illinois
Tel.: AMbassador 2-7091

A. J. Underwood
Midwestern Advertising Manager
3-210 General Motors Building
Detroit 2, Michigan
Tel.: TRinity 2-0606

SAE DETROIT OFFICE
R. C. Sackett, Staff Representative
808 New Center Bldg.
Tel.: TRinity 5-7495

SAE WESTERN BRANCH OFFICE
E. W. Rentz, Jr.
West Coast Manager
Petroleum Bldg.
714 West Olympic Blvd.
Los Angeles 15, Calif.
Tel.: RIchmond 9-6559

The Society is not responsible for statements or opinions advanced in papers or discussions at its meetings or in articles in the Journal.

All technical articles appearing in SAE Journal are indexed by Engineering Index, Inc.

Copyrighted 1956 Society of Automotive Engineers, Inc.

Please address all editorial, advertising, and SAE Special Publications mail to:
29 West 39 Street
New York 18, N. Y.

Contents—JUNE, 1956

More Miles Per Gallon Through Fuel Research—J. M. CAMPBELL 17

200 HP Gas Turbine Automobile—E. T. VINCENT, F. L. SCHWARTZ, CHARLES LIPSON, A. K. LAHTI, CHARLES HARRIS, and U. O. LAHTI 18

Aircraft Structures Must Fail Safe—J. F. McBREARTY 26

High Speed Light Weight V Diesels—E. C. GINN, W. F. BURROWS, and H. W. HANNERS 30

Steel Backed Aluminum Bearings—R. S. FRANK and W. J. LUX 37

Truck Cabs—B. C. HARRIS 39

Fight Against Fade—J. W. KINCHIN, T. H. THOMAS, D. P. DYER, C. L. EKSERGIAN, W. B. LOVE, and D. E. HOBSON 40

THE CLR Oil Test Engine—W. G. AINSLEY and A. E. CLEVELAND 46

The Philosophy of Reliability—CHARLES T. MORROW 48

Fatigue Failures—CHARLES M. SCHWARTZ 49

Allison Power Package for the Lockheed Electra Transport—R. M. HAZEN, DIMITRIUS GERDAN, and R. R. LaMOTTE 50

Fuels for Turbine Transports—HUGH HARVEY 55

GM's GMR 4-4 "Hyprex" is Free Piston Type Turbine Engine—A. F. UNDERWOOD 60

Processes for Tomorrow—T. R. LINTON 67

Fuselages—K. R. DERRYBERRY 69

Differential Gas Turbine—DAVID W. HUTCHINSON 70

Aeronautic Meeting Reveals Challenges Posed by the Jet Age 76

News of the 1956 SAE Aeronautic Production Forum 83

News of the 1956 SAE National Aeronautic Meeting 86

Report of the Seventh Annual Earthmoving Industry Conference 91

■

About SAE Members 96

SAE Section News 101

Technical Committee Progress 108

1956 SAE National Meetings Schedule 109

New Members Qualified 138

Applications Received 144

Society of Automotive Engineers, Inc.

George A. Delaney
President

John A. C. Warner
Secretary and Gen. Manager

B. B. Bachman
Treasurer

Planning for tomorrow • Producing for today!

For a third of a century Bendix Products Division has demonstrated time after time its ability to not only meet current production demands, but to actually anticipate future automotive requirements.

For example, Bendix* Power Braking and Power Steering are today two of the industry's most popular new car features because Bendix started planning them years ago.

Likewise, new products now being developed at Bendix Products Division may well be expected to make automotive headlines on future new car models.

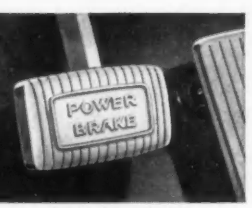
That this Bendix program of constant progress will continue is a certainty because looking ahead plays such a very important part of the job at Bendix.

*REG. U. S. PAT. OFF.

BENDIX PRODUCTS DIVISION **SOUTH BEND** INDIANA

Export Sales: Bendix International Division, 205 East 42nd Street, New York 17, N. Y.

TYPICAL EXAMPLES



Bendix Power Brakes

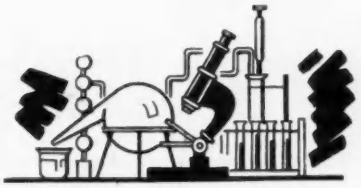
Bendix Power Steering

Bendix Products Division

Bendix AVIATION CORPORATION

BRAKES • POWER STEERING • POWER BRAKING • CONSTANT VELOCITY UNIVERSAL JOINTS • HYDRAULIC REMOTE CONTROLS

More Miles Per Gallon through Fuel Research



J. M. Campbell, Research Laboratories Division, General Motors Corp.

Based on paper "The Big Dividend from Research in the Greatest Power Industry in the World" presented at SAE Metropolitan Section Meeting, New York, Oct. 6, 1955.

Here's what's in store for fuels and the motorist in the next few years

IN THE NEXT FEW YEARS, as in the past 25 years, the automotive industry and the public will benefit greatly from organized research in automotive and petroleum laboratories. Billions of dollars saved by getting more miles per gallon of fuel will be passed along to the motorist. The nation's petroleum resources will be conserved, too.

★

The octane level of fuels will continue upward. However, the number of available hydrocarbons which have sufficient antiknock value and lead susceptibility to surpass 100 octane will diminish.

★

Efforts will continue to isomerize paraffinic hydrocarbons and to hydrogenate olefinic hydrocarbons to branched chain paraffinic hydrocarbons having higher lead susceptibility than the original olefins.

★

Tetraethyllead should become increasingly important as an ingredient of motor fuel because of the very high lead susceptibility of the branched chain paraffinic hydrocarbons in the high octane number range.

★

Aromatic hydrocarbons will present some problems because of their increased susceptibility to surface ignition. However, this problem is widely recognized and is being vigorously attacked on several fronts.

★

Surface ignition will be brought under control or entirely eliminated. This will be accomplished through use of new lubricating oils with less tendency to form combustion chamber deposits which are conducive to surface ignition. Controlling fuel composition and the use of additives are other ways by which surface ignition will be controlled.

★

A larger proportion of passenger cars will have engines of higher compression ratios. Raising compression ratio from 8/1 to 9/1 is equivalent to about three octane numbers. The cost of increasing octane number of the United States gasoline pool is about 50 million dollars per octane number. So, this compression ratio increment will have an annual potential value of about 150 million dollars.

★

New automatic transmission developments will achieve savings of 25 to 35% in fuel consumption.

★

For complete paper on which this abridgment is based write to SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.

Thermodynamic Stumbling Blocks

200-HP

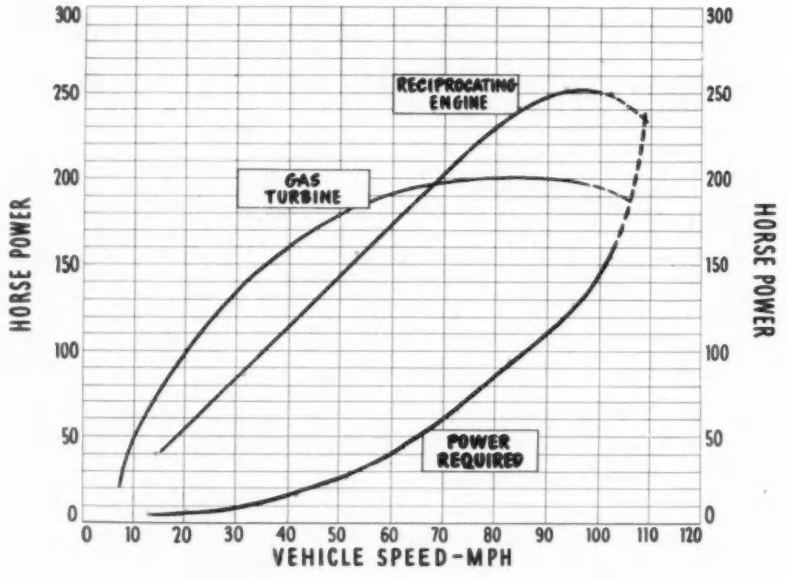


Fig. 1A — Comparison between a 275-hp reciprocating engine and a 200-hp gas turbine.

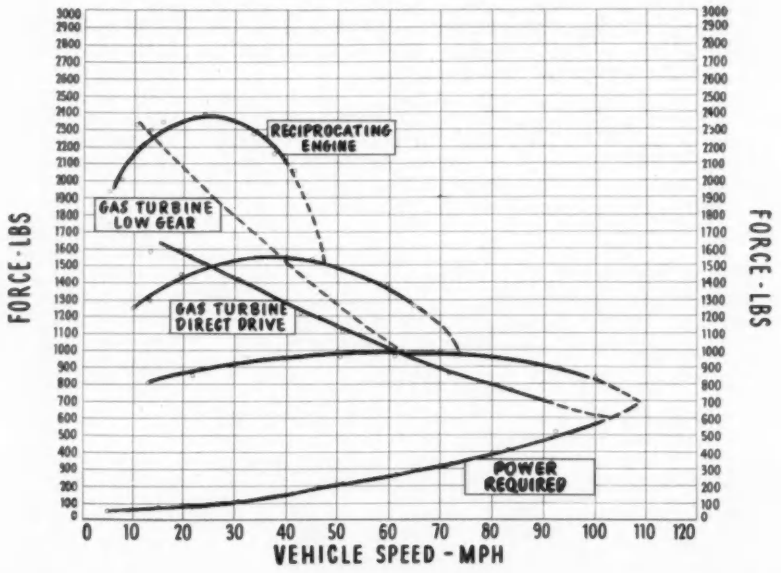


Fig. 1B — A 200-hp gas turbine has better torque characteristics than a 275-hp reciprocating engine.

To Designing a

Gas Turbine Automobile

E. T. Vincent, F. L. Schwartz, Charles Lipson, A. K. Lahti, Charles Harris, University of Michigan

U. O. Lahti, Consultants to Management, Inc.

Based on paper "The Next Decade and the Automobile" presented at SAE Annual Meeting, Detroit, Jan. 9, 1956.

AN efficient 200-hp gas turbine automobile may be on the road within the next decade if certain thermodynamic problems can be solved. Basically these problems arise from the high operating temperatures which are necessary to keep fuel consumption of a gas turbine as low as a reciprocating engine. One way of removing the high-temperature handicap is by using a regenerator. This increases the weight and size of the powerplant and requires very large exhaust pipes—all of which affect chassis and body design. Too, high operating temperatures require expensive heat-resistance materials or methods of cooling turbine blades and insulating the powerplant.

During the next decade two types of gas-turbine cars will probably evolve: a high-speed, large, highway cruiser, and a small, urban run-about with a top speed of about 70 mph. Neither of these vehicles will look very different from present-day automobiles despite that they will have to be designed specially around the turbine powerplant and accessories. If the powerplant is placed in front, the vehicle will probably be front-driven. If it is placed in the rear, the vehicle will probably use a rear drive. A major problem will be accommodating the large exhaust ducts that are necessary with a turbine and regenerator.

A 200-hp turbine will provide a top speed of 104 mph and a maximum driving force of 1505 lb. This is obtained without any other gear reduction except the one built into the engine—a 7.77 planetary gear set to cut down the 35,000 rpm turbine speed to 4500 rpm. If an additional reduction of 1.5 is added, the driving force is increased to 2320 lb, which is comparable to the force developed by a 275 hp reciprocating engine. (See Figs. 1A and 1B.)

Thus a 200-hp turbine should be able to perform as well or better than a 275-hp reciprocating engine.

Advantages of The Gas Turbine

The gas turbine powerplant has the following ad-vantages over a reciprocating engine:

Does not require much lubricating oil
The only lubricating oil needed is for two to four bearings and a gear box. It will not be necessary to change oil because of dirt or climate.

Does not require high octane fuel
Gas turbines will run successfully on medium octane fuels and fuels of medium volatility. So refining methods should be cheaper and fuel costs lower.

Smooth operation—no vibration
Because there are no reciprocating parts, the turbine is in perfect balance at all speeds and requires no special mounting pads.

Ignition is necessary only for starting
Only one spark plug and a very simple ignition system is required.

CONTINUED ON NEXT PAGE

Light weight

Gas turbines without a heat exchanger (driving an electric generator) have been built as light as .6 lb/hp. With a dual turbine wheel, specific weight is 1-2 lb/hp. (This is comparable to reciprocating engines, and considerably less than diesel engines.)

Small volume

Because of the high rotative speeds inherent in small gas turbines, their size is small. A heat exchanger will double the size of the unit.

Fewer parts

A gas turbine has less than ¼ as many parts as a reciprocating engine.

A compressor wheel, two turbine wheels, a combustion chamber, four bearings, and a case are the essential parts. Many parts can be made from castings, forgings, and sheet metal, keeping costs low.

Easy cold weather starting

Gas turbines become more efficient at lower ambient temperatures, so they are easier to start in cold weather. Too, less power is taken from the turbine to drive the compressor because at low temperatures less work is needed to compress air.

Easy to maintain

Because of fewer parts and rotating motion only, maintenance is easier and less costly than comparable diesel engines.

Does not require external cooling system

No cooling system is needed. (A small oil cooler may be used for cooling the bearing system.)

Clean exhaust

Since air fuel ratio is between 50 and 100, combustion efficiency is high (95%), giving a clean exhaust.

Excellent torque characteristics

The free wheel or driving turbine has maximum torque at zero speed, which is very desirable. Torque varies with the temperature and speed of the gas producer unit. So, one can brake the vehicle, speed up the gas producer and have a high torque when the brake is released.

Few gear changes

Gear shifting is not required for most normal operations although a second gear ratio may be desired for abnormally steep grades or pulling out of mud or snow.

Disadvantages of a Gas Turbine

The gas turbine powerplant has several disadvantages, too:

High gas temperatures

High gas temperatures are needed to make the turbine as efficient as a reciprocating engine. These temperatures may distort and corrode the combustion chamber, collectors, nozzles, blades and other parts. If a cooling system is installed, the heat loss may reduce over-all thermodynamic efficiency. One solution that will permit the use of higher temperatures may be to use a regenerator.

High specific fuel consumption

Since the operating gas temperature cannot be increased (unless some means is found for cooling the turbine blades) specific fuel consumption at full turbine power of an unregenerated cycle will be 1/3 more than a reciprocating engine. And at part throttle the gas turbine has even worse fuel economy.

Expensive materials of construction

Materials currently used in gas turbines are more expensive than the cast iron usually used in reciprocating engines. Critical parts (blades, discs, combustion chamber liners) subjected to high temperatures and stresses need expensive heat-resistant alloys. Even if some parts can be made of less expensive materials weight will increase. If a satisfactory cooling solution could be found this problem would solve itself.

Large gas flow

The airflow of a simple gas turbine is five or six times that of a reciprocating engine. The incoming air — about 8000 lb/hr — must be cleaned quickly and the exhaust gases require large exhaust pipes. Even multiple stage centrifugal machines and new compressor designs will not reduce airflow very much. If pressure ratio is increased to 12/1 the turbine would still need 45 lb/hr/hp of air. Use of a regenerator increases airflow requirements to between 60 and 90 lb/hr/hp.

High rotative speeds

The automobile gas turbine rotates at 30,000 to 40,000 rpm. These high speeds require either a high speed rear axle, or a high ratio gear box and transmission. The first would involve new small diameter wheels and tires, and less ground clearance. The second will involve new reduction gears, with super accuracy to keep tooth load down at high speeds, or new gear materials and designs.

Need for insulation

Gas turbines have a high pitched and piercing sound. So sound proofing in the engine compartment and inlet silencers will probably be needed. Insulation from the high combustion chamber temperatures will also be needed and the exhaust ducts must be insulated to protect the passengers, body paint, etc., from heat.

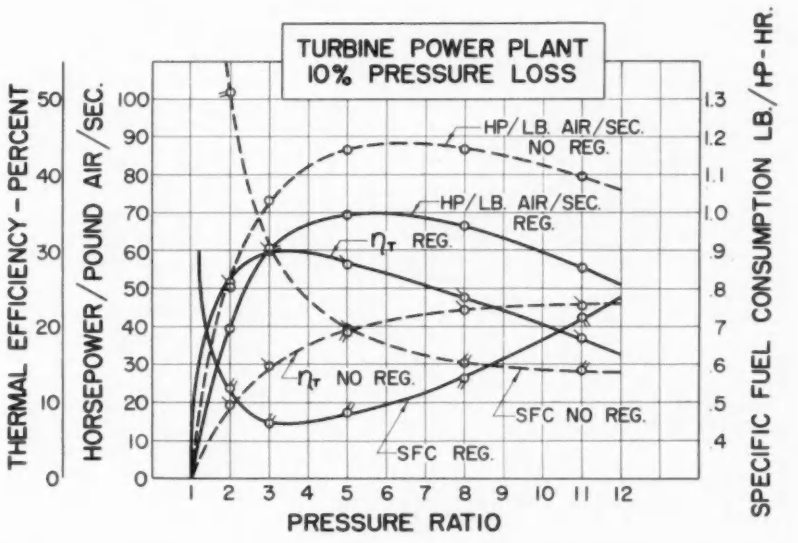


Fig. 2—Comparison of simple cycle and regenerated cycle gas turbine performances. To equal piston engine economy a regenerator will probably be necessary.

The Powerplant

A gas turbine composed of a centrifugal compressor and radial inward flow turbine using a regeneration cycle appears to hold the best promise for powering a 200 hp gas-turbine automobile of the future. This conclusion was arrived at after analysing several possible types of gas turbine installations.

A power package without a regenerator would probably have the following specifications:

Brake horsepower	200 hp
Maximum gas temperature	2000 F
Pressure ratio	8/1
Ambient air	60 F at 14.7 psi
Compressor efficiency	82%
Turbine efficiency	86%
Pressure drop in combustion	3.5%
Airflow	1.63 lb/sec
Temperature leaving compressor	861 deg abs
Specific fuel consumption	0.60 lb/bhp/hr
Weight of unit	160 lb

A comparison of a simple cycle power package and one using a regenerator is shown in Fig. 2. These data indicate that:

1. It will be difficult for a gas turbine to equal the fuel economy of a reciprocating engine unless it has a well-designed regenerator.
2. A high compression ratio is desired for a simple cycle.
3. A low compression ratio is necessary for good efficiency of a regenerated cycle.
4. Large airflow capacity (40–90 lb/bhp/hr) is necessary for any type of gas turbine.

So a gas turbine operating at 2000 F with a compression ratio of 8 or 9/1 without regeneration, and 3 or 4/1 with regeneration will perform comparably to a piston engine. For these temperatures and pressure ratios an *axial flow compressor* would best suit the simple cycle powerplant while a *centrifugal compressor* would be ideal when a regenerator is used.

A single stage centrifugal compressor costs less, is easy to maintain and repair, and operates over a large range without surging. If its impeller size and passages are modified and two stages of compression are used, the centrifugal compressor can be used for both simple and regenerative cycles.

There are two types of combustion chambers in use today. In the *can type* the gas flow is divided into several cylindrical chambers surrounding the machine. Fuel is burned in each. But taking the air out of its direct path to the turbine, adding heat, and returning it back to its axial direction involves some losses.

The *annular chamber* surrounds the axis of rotation. The compressor delivers air axially into this chamber and the fuel is added and burned with little disturbance of the direct, streamlined flow from the compressor inlet to the turbine exit.

The *can type* is best suited to the centrifugal compressor. It is much simpler to supply fuel through one nozzle into the air in a single can than to distribute the fuel efficiently in an annular chamber by using a multi-point injection. The *can type* costs less and is easier to maintain, too.

If a direct mechanical drive between the turbine and the rear axle is desired, two turbine wheels are necessary: one drives the compressor and one drives the vehicle. The combination of compressor-combustion chamber and turbine wheel produces hot gases which drive the second turbine geared to the rear axle.

There are two types of turbine wheels: The *radial inflow turbine* is similar to a centrifugal compressor but the gas flows in the opposite direction, and the diffuser vanes of the compressor are replaced by nozzles in the turbine. It can be made cheaper and handle a larger pressure ratio per stage with high

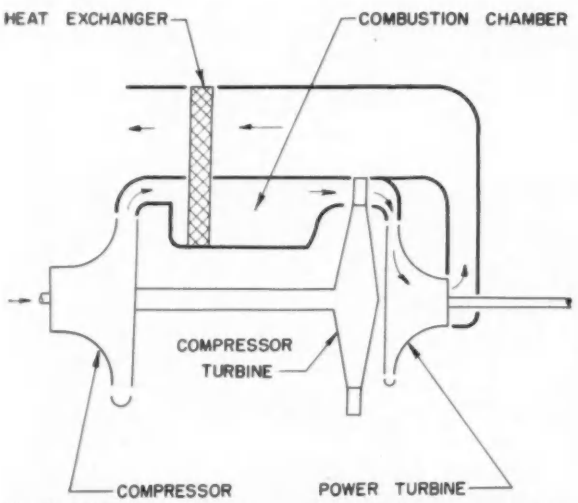


Fig. 3—Schematic of turbine powerplant showing compressor, heat exchanger, axial flow compressor turbine, and radial flow power turbine.

efficiency than the *axial flow*. It is less susceptible to a drop in efficiency at light load, and it can use variable area nozzles easily.

Usually an *axial flow* turbine is used with the gas producer and a *radial flow* turbine in the power unit, as shown in Fig. 3. With a radial flow turbine driving the wheels, the vehicle can be braked dynamically by reversing the nozzle vanes.

Fuel economy, especially at part load, is possible only if a heat exchanger is used to recover some of the energy in the exhaust that would otherwise be wasted. Since a high inlet temperature is used for maximum efficiency, and the drop in temperature through the turbine is low, much heat energy escapes in the exhaust unless a regenerator is used.

Two types of regenerators have been built: A *surface plate* type uses small tubes or extended surfaces on plates without any moving parts (Fig. 4). Heat is transferred from the hot exhaust gas through a boundary layer on a separating surface, through the surface, through a second boundary layer of the compressed air leading from the compressor. For a high rate of heat transfer a large area of extended surface is needed. This is heavy and expensive to manufacture.

Another type of regenerator uses a light weight and compact *rotating matrix*, as shown in Fig. 5. It allows only a very small pressure drop, and is 80–90% effective. One difficulty is providing an adequate seal between the rotating matrix and the stationary ducts that will prevent more than 2 or 3% loss by seal leakage.

The disc rotates between 10 and 20 rpm. As the matrix enters the high pressure air passage, it is cooled by the air flowing through the matrix and the air is heated. Then the matrix continues to revolve past a seal and enters the hot gas duct where it is heated and the hot gas is cooled. In this manner each element of the matrix is alternately heated and cooled, thereby transferring heat from the hot, low pressure gas to the cold, high pressure air. From 1 to 2 sq ft of matrix frontal area in the disc type of heat exchanger is needed per 1 lb/sec airflow. A 200-hp gas turbine with an 85% effective regenerator and 4/1 pressure ratio and air flow of 3 lb/sec would require a disc type rotary regenerator with a diameter of 28 in. and length of 12 in. The future of the gas turbine will probably depend upon whether an efficient heat exchanger can be developed.

By using a free piston engine to produce the hot gas and piping the gas to a turbine which drives the wheel even better fuel economy and excellent torque characteristics may be achieved. A free piston engine-turbine combination does not use up power for driving an air compressor. Since exhaust temperatures are lower, low cost materials can be used

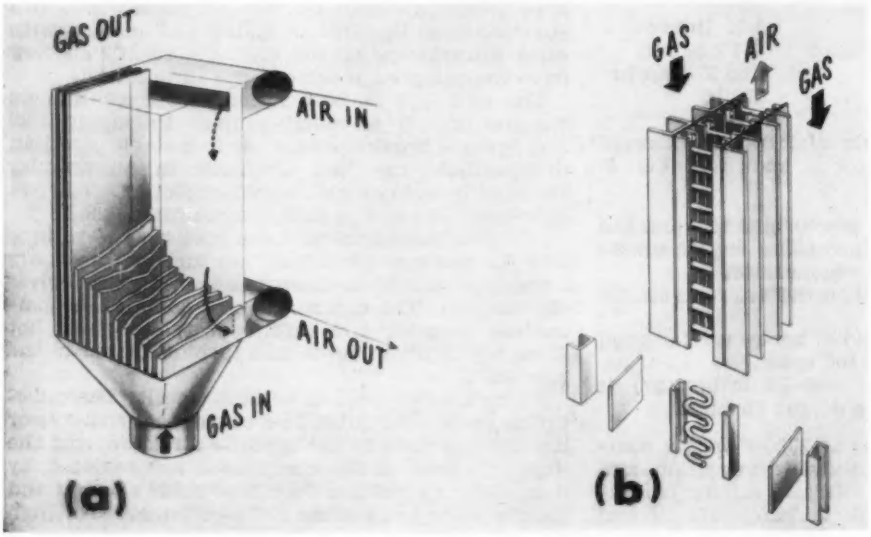


Fig. 4—Two types of plate regenerators: (a) counterflow of air and gases shortens the unit's length (b) extended surface for a plate exchanger.

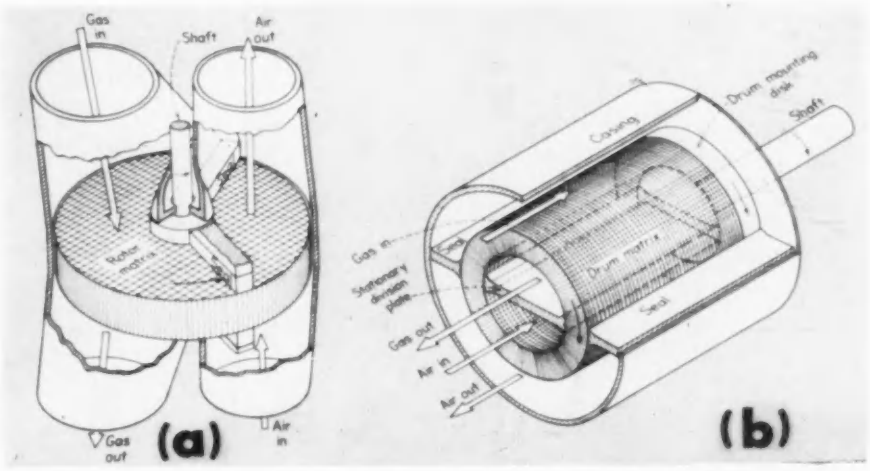


Fig. 5—Two types of rotary regenerator: (a) disc or rotor matrix passes air and gas (b) drum matrix turns in a partitioned casting.

in the turbine following a free piston engine. It is expected that a free piston engine and turbine will give 200 shp and will have a specific fuel consumption of 135 lb/hp-hr. It will weigh 600 lb, occupy a space of 12 in. diameter × 40 in. length and have excellent torque characteristics. See page 60 of this issue for a description of a free-piston engine installation.

Another possibility for a prime mover is using a gas turbine to drive an electric generator which charges batteries to 200 v. The vehicle is driven by electric motors on the rear axle.

The Chassis

The design of an automobile chassis for a gas turbine installation will depend upon the size of the turbine, and whether a regenerator is included. Assuming that a regenerator is needed, and that the turbine will have to develop 300 hp, Fig. 6 shows a schematic set up of the powerplant with approximate duct sizes. To keep pressure loss in the piping to a minimum the heat exchanger should be kept as close to the turbine as possible. Otherwise the arrangement can be varied as shown in Fig. 7.

These turbine arrangements can be placed in front or in the rear of the vehicle. Since the tread in current cars is around 65 in. the first combination, Fig. 7A, probably can't be installed in the front.

In the rear, the height of the trunk compartment in current cars is about the same as the hood—about 20 in. By bringing the regenerators of the first combination (Fig. 7A) radially up, the width can be reduced to less than 60 in. So, the trunk width is sufficient for all combinations. The maximum length of the gas turbine units in Fig. 7 is 45 in. This is within the rear overhang of the average car.

The trunk may not be high enough for the gas turbine, however. The body stylist could increase the height of the trunk compartment or the engine could be installed lower than the floor panel provided road clearance is not reduced to less than 4 or 5 in.

When a free wheel turbine is used a clutch is not

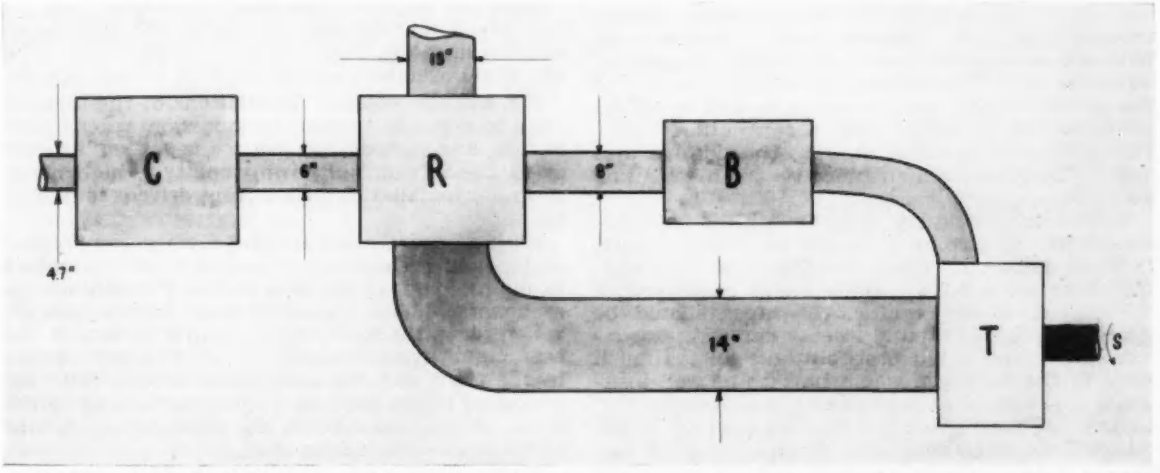


Fig. 6—Schematic of the 300-hp turbine with approximate duct sizes. C—compressor, R—regenerator, B—burner, T—turbine. A 200-hp turbine would require one 8-in. exhaust pipe or two 5.7-in. pipes. Pipes should have no sharp bends and be well-insulated.

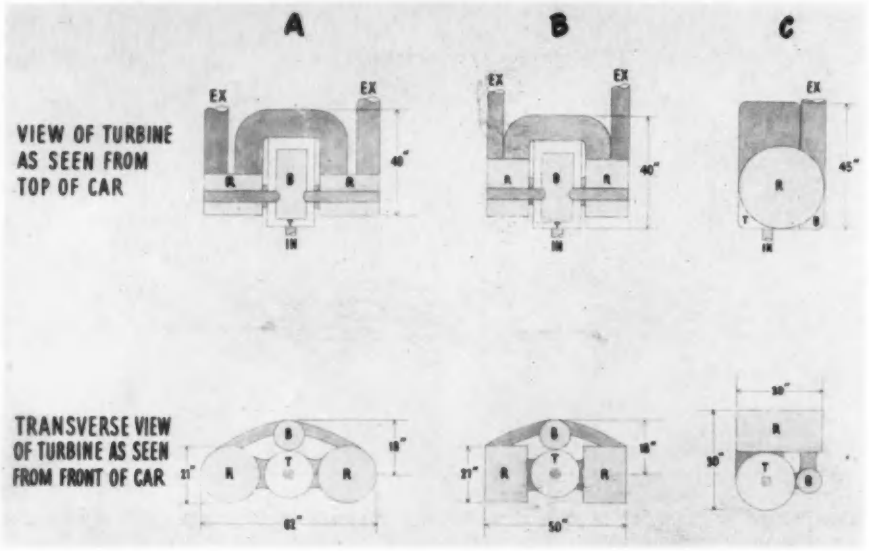


Fig. 7—The compressor, turbine, and regenerator may be arranged in several ways.

necessary even though a reverse gear and one forward speed gear would be required. The transmission, therefore would be small. This would fit behind the front-installed engine without disturbing the front seat floor panel.

With the engine in the front the car can be driven from the rear or from the front. By installing the engine backwards—that is, placing the output shaft side and the transmission in the front—and using a separate shaft from the transmission to drive each wheel, the car can be front-driven. If it is necessary to push the turbine forward for proper weight distribution, the drive shafts could be arranged at an angle.

With the engine in the rear the only practical possibility is a rear drive. If a conventional rear axle is used, angle variations will be large, in which case a constant velocity joint will be necessary. Another possibility is to place the turbine transversely and use an offset differential.

It might be possible to combine the turbine, transmission, and differential into a single unit. With this arrangement, an independent suspension would be used. The differential would be a part of the sprung weight, and the rear axle and wheel assembly would be lighter than a conventional unit. This arrangement might improve the ride but also might introduce some difficulty in distributing weight.

When one exhaust pipe is used with the front-installed 200-hp turbine, it should be between 8 and 11 in. in diameter. When two pipes are used each should be about 5.7 in. Since sharp bends reduce the output of the engine, the pipes should be straight or turned around in easy curves.

A single pipe would probably take up too much room in the body and would have to be well-insulated. Perhaps a rectangular pipe—approximately 3×50 in.—placed under the floor between the frame side rails might be adequate. However, it will interfere with the frame x-member and will cut down road clearance.

If the gases are exhausted from the side, there is danger of burning the paint of the car next to it. If exhaust is from under the car, the high exhaust temperatures may injure the road surface or produce excessive dust on dirt roads.

A vertical exhaust pipe, similar to those used on trucks, is a possibility.

A rear installation simplifies the exhaust problem. Exhaust pipes can be directed from any point in the rear.

With the gas turbine and the regenerator placed in front, total weight will not be very different from the present powerplant. Distribution therefore will probably be 55% front and 45% rear for curb weight and 50–50% for a fully loaded car. This will introduce greater slip angle in the front than in the rear and will result in understeering characteristics. The car however will be stable at high speeds.

With the engine in the rear the weight distribution would probably be 45% front, 55% rear (curb weight) and 40% front, 60% rear (full load). The car would oversteer and be unstable at high speeds.

Fig. 8 shows possible installations of the turbine. With a unit gas turbine (compressor, regenerator, burner, and turbine) placed in the rear and a rear drive, the only difficulty is instability at high speed. A similar installation with a front drive is impractical.

With a separate gas turbine (compressor, regenerator, and turbine comprising one unit connected by piping to a free wheeling turbine) conditions are even worse. With the compression turbine and regenerator in the front and the power turbine in the rear, piping presents a problem. With power turbine in the front and the compressor turbine with regenerator in the rear, piping and stability are problems. With a rear drive, the shaft tunnel can be added to the above difficulties.

Probably the turbine will be placed in the front and the vehicle front-driven, or placed in the rear

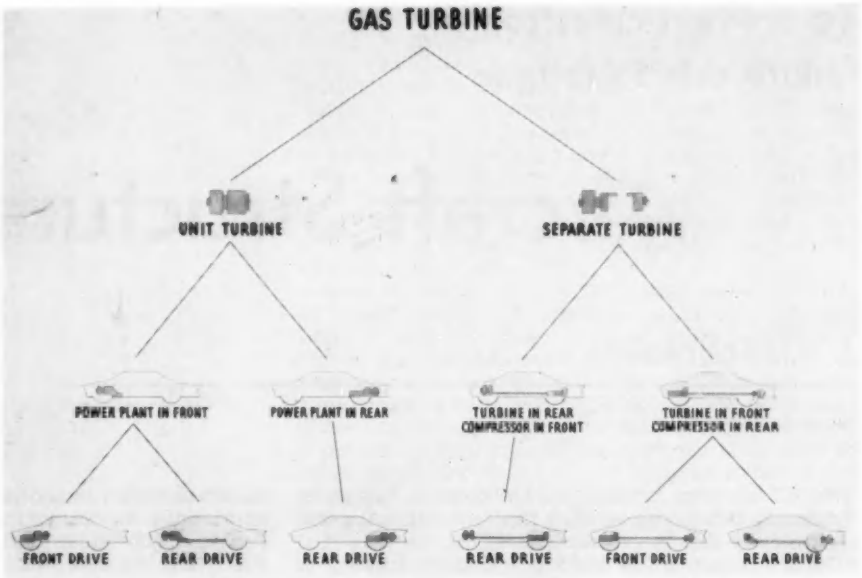


Fig. 8—Six possible installations of unit and separate gas turbines.

with a rear drive. The first vehicle should have good stability at high speeds, but there will be exhaust pipe problems. The second vehicle will have no exhaust problems, but will be unstable at high speeds.

Although these difficulties may be solved and a compromise vehicle evolved, it may well be that instead, two separate types of vehicles will emerge.

The Body

A high-speed highway cruiser will have a 200-hp turbine in front. To provide more interior space the propeller shaft tunnel will be eliminated and the car will be front driven. Weight distribution would be essentially the same as in present cars.

A small, city run-about may have the turbine located in the rear and be rear driven. Exhaust will be no problem but the car may be unstable at high speeds, so it's top speed may be limited to 70 mph. Independent suspension, better aerodynamic characteristics, and moving the passengers and accessories as far front as possible to improve weight distribution may be necessary.

Fig. 9 is a silhouette of a small gas turbine runabout compared with a present day station wagon. Fig. 10 is one conception of the large vehicle, showing gas turbine components and the passenger compartment. The hood lines are longer since the extended space in front of the turbine is needed for the front wheel drive mechanism and air conditioning equipment. Hood is lower since no radiator is necessary.

It can be seen that the gas turbine powerplant in itself will not greatly affect the appearance of the future car. Most changes in styling will probably be dictated by social pressures, such as human needs and wishes, rather than mechanics.

For complete paper on which this abridgment is based, write SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.

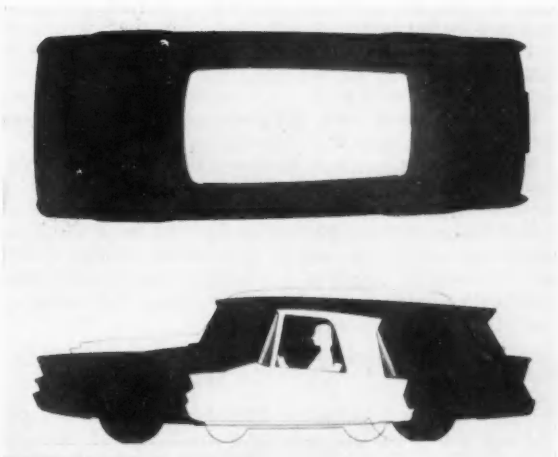


Fig. 9—The urban gas-turbine run-about will be much smaller than present day cars. It will have a top speed of 70 mph and probably be driven by batteries charged to 200 V by a gas turbine.

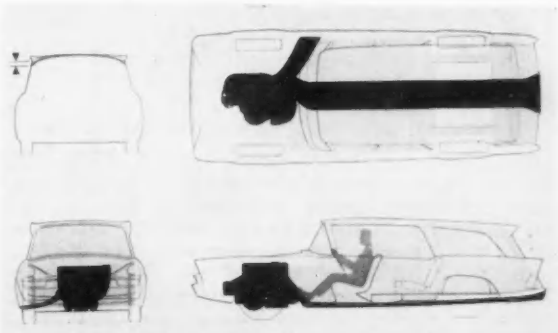


Fig. 10—The large highway cruiser will be designed for high speeds and passenger comfort. Powerplant will be placed far forward (using angled drive axles) to give the passenger compartment more space.

To prevent catastrophic failure due to fatigue

Aircraft Structures Must

J. F. McBrearty, Lockheed Aircraft Corp.

Excerpts from paper "Fatigue and Fail Safe Airframe Design" presented at SAE Golden Anniversary Aeronautic Meeting, Los Angeles, Oct. 14, 1955.

THERE are two contrasting methods of designing aircraft structures so that they do not fail catastrophically due to repeated stressing.

In one method the expected loading history of the structure is estimated . . . the structure is tested for these loads . . . and a "safe life" is then chosen. The structure is replaced when this safe life is reached in service.

The other method is to design the structure so that it can carry its service load even after one of its elements has failed.

Of the two methods, the fail-safe method appears to be "safer" than the safe life method.

The safe life method assumes that no serious fatigue crack will occur within a certain period of service. Fundamentally, the method is an analytical one because, although many of its steps may be based on tests, the crucial step of determining the safe life itself requires the analytical or arbitrary provision for many variables. Putting this another way, the big question is

$$\text{Safe Life} = \frac{\text{Laboratory (or Predicted or Record) Life}}{?}$$

On the determination of this denominator hinges the adequacy of the safe life method. If the approach is based on a laboratory test of the structure under repeated loads then the factor in the denominator must account for the following:

Statistical variation in specimens
Loads omitted in test
Thermal effects
Corrosion or time-dependent effects
Repairs and service modifications
Effects of high "one-time" loads
Statistical variations in loading experiences

There are undoubtedly many others. Thus what must the factor be? A scatter in life among laboratory specimens under controlled conditions of 3 is not uncommon. In the Comet tests the laboratory life of the fuselage was 2.4 times that of the Elba failure and 3.4 times that of the Naples failure. Hence the factor could not logically be less than 3 or 4.

In the Second Barnwell Lecture, Walter Tye says:

"Statistical methods had been used by Kennedy to determine the additional allowance which should be made when information was limited to a few specimens. His calculations had been used to obtain the example illustrated in the diagram [Fig. 1]. Assuming the results of n tests, these indicated an average life represented by 1.0, and a scatter such that a life of 0.32 of average occurred once in 1000 occasions. It was possible that the true mean could be lower or higher, and the scatter greater or less than the experimental values, and so there was no certainty that the safe life would be 0.32. Using statistical methods we could say with 90% confidence (that is, with nine chances out of 10 of being right) the safe life indicated by the experimental results would be no lower than the curve shown in Fig. 1. Thus, if there were but six results from which a safe life of 0.32 were deduced, there was in fact a 1 in 10 chance that the life would be only 0.14.

"This very discouraging conclusion implied among other things that one could feel more confidence than was justified when a standardized degree of scatter was assumed, even when the experimental results supported the use of a standard value. It also meant that if the component indicated low scatter it would be unwise to accept this indication unless many results were available."

It is fairly obvious that we cannot test a great number of fuselages or wings or other components in order to pin down this effect accurately. Even so, there will remain at least the other variables in the list above. For example, acoustic vibrations from propeller, turbine, or jet efflux must be considered in either the test or in the factor chosen. Thermal stresses from changing temperature environment have their effect. Furthermore, it is known that specimens exhibit a longer lifetime when tested in a vacuum than when tested in air, indicating that the actual consumption of fatigue life is a stress-corrosion process and is thus time dependent. Repairs and modifications are a practical consideration—a fuselage or wing could scarcely be retested under repeated loads each time a different window arrangement or a new door or such practical alteration occurred. The question of what to do about a severe gust experience or a hard landing that produces limit loads or even minor damage in service presents itself.

Must tests be rerun? The aviation press has reported that the British feel that two structures must

Fail Safe

be tested, one statically and one in fatigue, rather than one structure for both tests because the static test would invalidate the fatigue results. A high static load in service would then presumably invalidate the safe life for the aircraft on which it occurred.

Thus, the determination of the factor for relating laboratory life to a safe life is a most difficult process and, if safety is to depend on this factor, it must be chosen conservatively. Again the aviation press reports that the British feel the factor cannot safely be less than 9.

This same discussion applies and many of these same variables enter the problem when any of the variants of this basic approach are followed. For example, if an instrument is installed to record the actual stresses or accelerations experienced in the aircraft, this can minimize the error in determining the load history but cannot account for such influences as the statistical variation in material life-time, time-dependent effects on the material, or repairs to the structure. At the same time it introduces the new variables of instrument response, reliability, and decisive location.

A safe life factor inherently means that when the safe life point is reached in service all the structures have life remaining and many structures which have not actually experienced the effects provided for will have consumed only a small fraction of their useful life and yet must be retired or replaced. This is economic waste. Yet it is the price for safety under this method.

Even assuming a safe life could be established to guard completely against catastrophic fatigue failure, there are other sources of structural damage. Trivial as they are in themselves, they cannot be permitted to destroy the aircraft. For example, the fuselage must not be destroyed by a turbine bucket or even a thrown propeller blade. Certainly a pressure cabin should not blow up if pierced by small arms fire from, say, a demented passenger. Similarly a wing should not be destroyed by the presence of unnoticed ground damage from a loading truck or similar event.

Summing up, therefore, it is concluded that the safe life method is impractical as a means *to provide safety from catastrophic failure.*

In one form or another it must be used by the designer, however, to provide a structure as free from fatigue cracking as the state of the art, the economics of the airplane, and the manufacturer's reputation for a reliable product will allow. In this function, methods available *are* adequate.

The Fail-Safe Method

The method which appears to satisfy the need for a practical and sound safeguard against catastrophic failure from fatigue cracking or other reasonable damage is the "fail-safe" method. A structure de-

CONTINUED ON PAGE 29

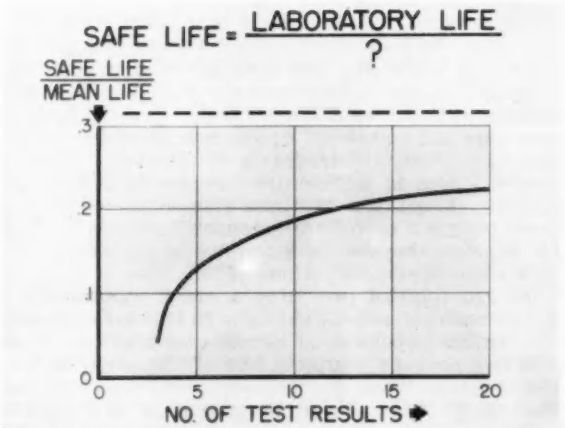


Fig. 1—In safe-life method, one must make extra allowance when "safe life" is determined from tests on only a few specimens. In Tye's example, results of many tests indicated a mean life represented by 1.0. Scatter was such that a life of 0.32 occurred once in 1000 times. True mean life and true scatter might be higher or lower. Statistical methods show that, if the safe-life figure of 0.32 resulted from fewer tests, actual safe life would be no lower than the curve in nine chances out of 10. In other words, if the safe life of 0.32 were deduced from six test results there is a one in 10 chance that life would not exceed 0.14.

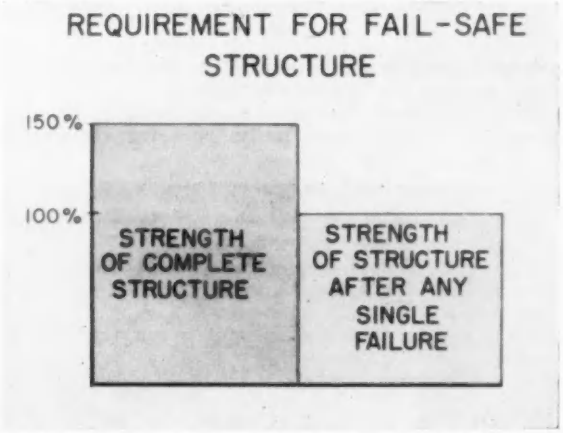
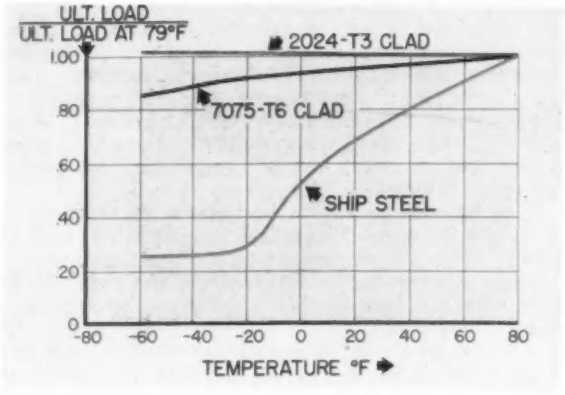


Fig. 2—In fail-safe method the structure is designed to sustain the maximum expected load with one member failed. Complete structure will withstand more than design limit load.

The penalty of the over-designed structure is added weight, of course. But this can be minimized by selecting materials for their ability to fail safe, by choosing stress level wisely, and by exercising design ingenuity in arranging multiple load paths.

The fail-safe method is a more practical method of providing safety from catastrophic failure than the safe-life method of design.

Tips On Fail-Safe Design

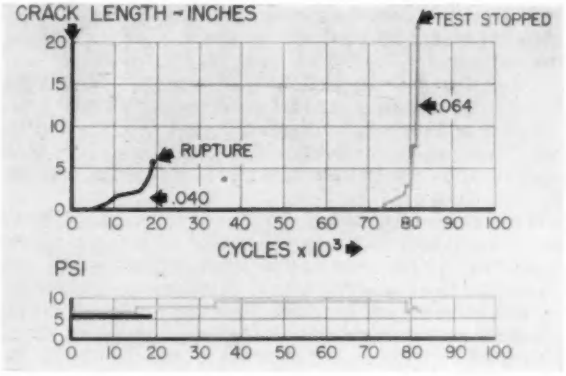


Materials show considerable difference in their ability to fail safe. For example, other things being equal, 2024 aluminum appears to require a greater static load to produce initial cracking, to sustain a greater crack before rupture, to support a greater static load at rupture, to be less affected by low temperatures, and to have a slower rate of crack growth under repeated stresses than does 7075 aluminum sheet material.

This chart shows that the strength of damaged 2024 sheet material is unaffected by temperatures as low as – 60 F while 7075 damaged sheet, weaker at room temperature than 2024, is further weakened about 15% at the low temperature. Data from similar tests on ship steel show an enormous reduction in the strength of cracked material at low temperature.

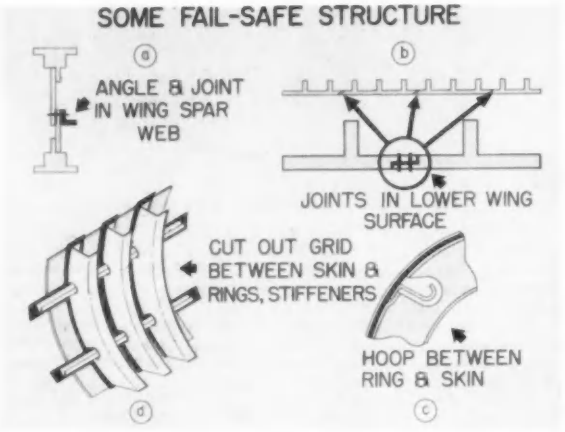
A properly chosen stress level can produce a fail-safe design in a multi-load path structure. First indications are that this stress level is, as might be expected, below the nominal ultimate strength of the undamaged elements. A weight cost is thus indicated, which research and design ingenuity must minimize.

This plot shows some Lockheed test results of full-scale fuselage pressure panels. These two panels were identical except for the skin gage. The thinner panel ruptured under a pressure of 5.7 psi and a nominal hoop stress of 9200 psi when the crack had grown to about 6 in. The thicker panel (hoop stress of 5750 psi) did not rupture even when the crack had been extended to about 22 in. The test was stopped due to insufficient air supply. Absence of rupture in spite of such obvious damage is indeed indication of a fail-safe structure.



Design ingenuity can minimize the weight price that must be paid for fail-safe structure.

A fail-safe structure must fundamentally be composed of multiple-load paths or several elements such that when any one fails the structure suffers only in degree. This criterion does not rule out structures with single large members provided these members are composed of discrete elements whose individual failure leaves a reasonable member strength and is sufficiently obvious to assure immediate detection. Multiple elements present one form of crack or failure "stopper." There is room for considerable design ingenuity to achieve a fail-safe structure by variations of this idea.


SOME FAIL-SAFE STRUCTURE
ANGLE & JOINT IN WING SPAR WEB
JOINTS IN LOWER WING SURFACE
CUT OUT GRID BETWEEN SKIN & RINGS, STIFFENERS
HOOP BETWEEN RING & SKIN

One method of providing a crack stopper for a wing shear web appears in (a). In this arrangement the stiffener operates in service at a very low stress and can prevent complete loss of the shear web in the event the lower spar cap ruptures for any reason. Sketch (b) illustrates an arrangement of integrally stiffened surface into segments proportioned and joined such that any segment can fail completely without major loss in total strength. Sketch (c) illustrates pressure cabin hoop strips designed to help support hoop pressure loads in case of skin failure. Sketch (d) indicates how this idea might be extended to a grid arrangement to avoid joggling or shimming the stiffeners.

CONTINUED FROM PAGE 27

signed according to this method can carry an honorable service load even after one of its elements is ruptured. Fig. 2 illustrates this. The complete structure will sustain 150% of maximum expected (limit design) loads. With any one of its elements failed, it will sustain approximately limit loads.

This design philosophy is not new, although its application to aircraft structure is new. It is based on the assumption that mechanical and human failures will occur and the airframe system must be prepared to cope with them. When this philosophy is examined it will be found that what measure of safety in aircraft operation has been achieved is due to a fail-safe philosophy. Multiple engines, dual controls, emergency systems, and alternate airports are examples of this philosophy.

In fact, the catastrophic fatigue failures that have occurred around the world can be traced to the absence of this feature. On the other hand, the serious failures which have occurred without producing catastrophe were certainly not the result of a safe-life approach.

The only practical answer to the safety problem generated by fatigue cracking and accidental damage is a fail-safe structure. Much of the structure of today's airplanes is now fail safe (although perhaps not intentionally so). Rather simple research, testing, and analysis will show the way to a completely fail-safe airframe.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

A Technique for Fail-Safe Monitoring

Discussion by William G. Rowell, Scully Signal Co., Melrose, Mass.

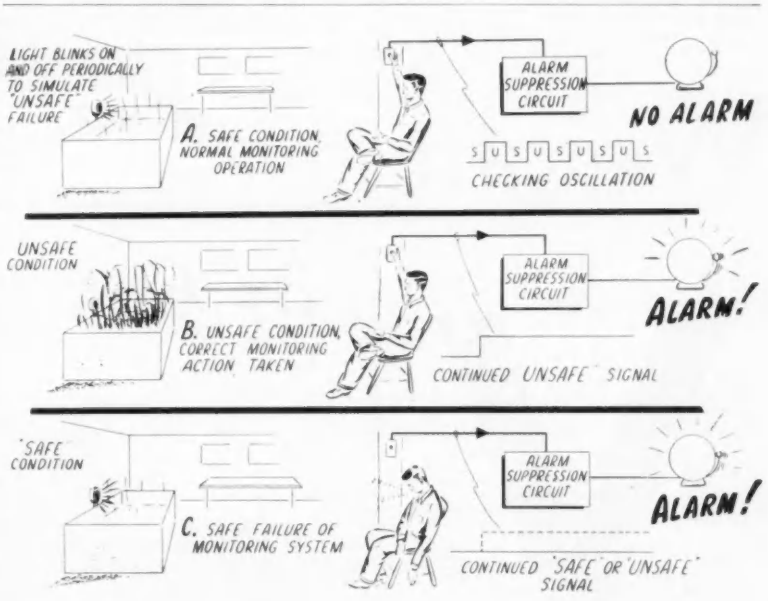
ONE way to make equipment protective devices and monitoring systems fail-safe is to have them check themselves continually by periodically simulating the dangerous conditions they are designed to detect. This is the basis for the new Scully-Rowell fail-safe monitoring technique.

We can illustrate by an example using a human monitor. Say he is instructed to watch a vat of potentially explosive chemicals and push an alarm button if the vat contents ignite. There is a risk that he may fall asleep, miss the onset of an explosion, and fail to press the button.

To avoid this risk, we can periodically flash a light simulating the unsafe flame condition and instruct the monitor to respond to this, too. To respond to this periodic unsafe input signal, the monitor must remain alert and generate a continual safe—unsafe—safe—unsafe . . . oscillation. To hold off the warning signal during the short periods of simulated danger, we can install an alarm suppression circuit.

If the monitor, whether human or not, responds properly to a simulated danger, the monitor will respond to a real danger when it occurs. If either (1) the safe condition being sensed ceases or (2) the monitoring system itself fails, the resulting steady signal allows the alarm to sound or initiates corrective action.

The safe-unsafe oscillation may be developed by a free-running perturbation device at the monitor input, or by the use of feedback to produce a relaxation oscillation within the monitoring system. The period of oscillation can be designed to meet the requirements of the particular control system, anywhere from hours to microseconds.


LIGHT BLINKS ON AND OFF PERIODICALLY TO SIMULATE "UNSAFE" FAILURE
A. SAFE CONDITION, NORMAL MONITORING OPERATION
ALARM SUPPRESSION CIRCUIT
NO ALARM
S U S U S U S U S
CHECKING OSCILLATION
UNSAFE CONDITION
B. UNSAFE CONDITION, CORRECT MONITORING ACTION TAKEN
ALARM SUPPRESSION CIRCUIT
ALARM!
CONTINUED "UNSAFE" SIGNAL
"SAFE" CONDITION
C. SAFE FAILURE OF MONITORING SYSTEM
ALARM SUPPRESSION CIRCUIT
ALARM!
CONTINUED "SAFE" OR "UNSAFE" SIGNAL

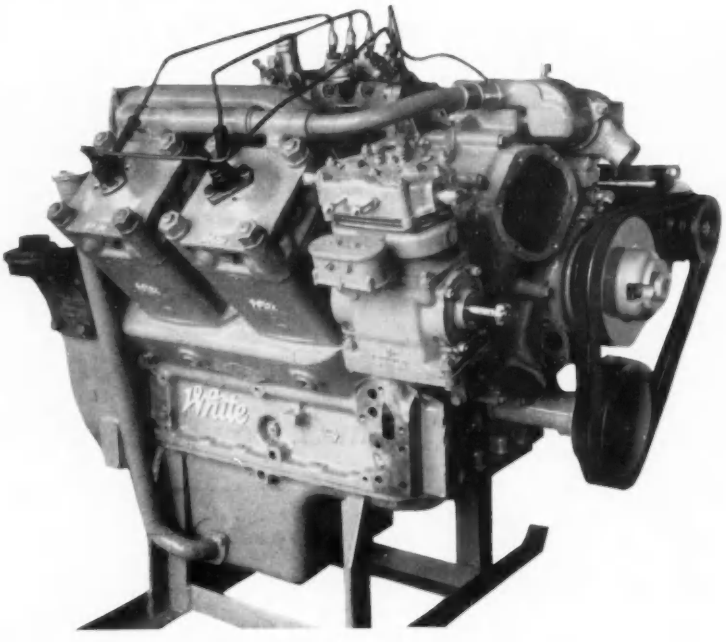
The technique can be used with electronic, electrical, mechanical, pneumatic, hydraulic, and nuclear systems, and can monitor heat, flame, current or voltage, force or pressure, or any other physical condition.

To check pressure, for example, the condition of low or high pressure can be simulated with a piston or a piezoelectric crystal. The operability of a temperature monitoring system can be continually proved by use of an auxiliary temperature source in the vicinity of the temperature pickup.

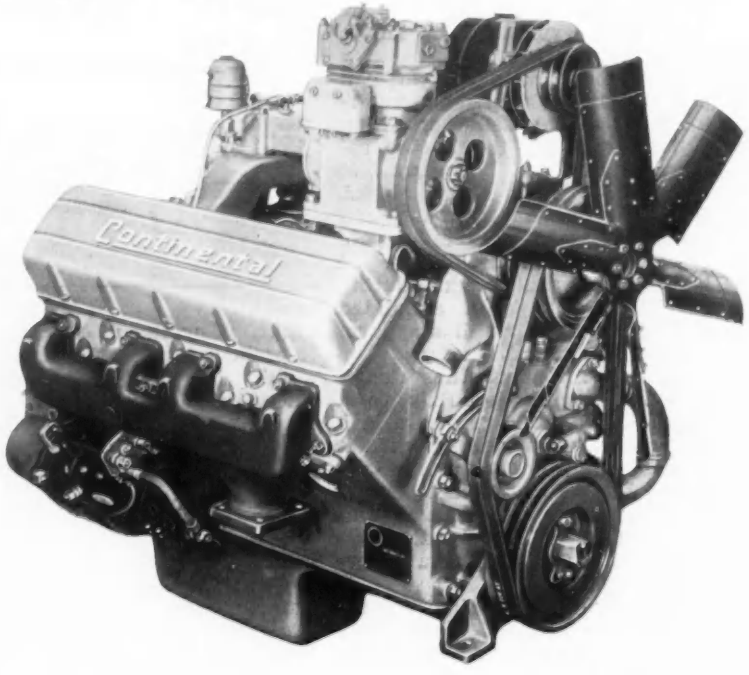
Patents covering the Scully-Rowell fail-safe technique are now pending in 10 countries. The first license, a non-exclusive one, has already been granted to a manufacturer of automatic controls.

High Speed Light Weight V Diesels

By White . . .



By Continental . . .



W. F. Burrows and H. W. Hanners,

Diesel Engine Division, White Motor Co.

Based on paper "Design and Development Experience—White V-106 Diesel" presented at SAE Golden Anniversary Diesel Engine Meeting, St. Louis, Nov. 3, 1955.

THE WHITE V-106 diesel engine is a two-cycle loop-scavenged engine without valves, valve gear, or camshaft. Individual cylinders can be replaced without disassembling the connecting rods or removing the oil pan. These special features permit minor repairs to be made while the engine is in the truck and eliminates interchanging engines except for major overhauls.

The 4-cylinder 170-hp engine weighs 1090 lb when made principally of aluminum, and 1355 lb for the same horsepower when some of the major components are cast iron. The 6-cylinder, 255-hp engine weighs 1530 lb (principally aluminum) and 1900 lb (cast iron). These weights include all installation accessories except the clutch.

The over-all dimensions of the V-106 are:

	4-cylinder	6-cylinder
Length	42-7/8 in.	52-1/2 in.
Width	36-1/2 in.	36-1/2 in.
Height	39-13/16 in.	39-13/16 in.

This engine is designed so that it consumes the least fuel in the speed range in which it is most used. Fig. 1 shows fuel consumption characteristics.

Basically, the White V-106 is the European Krauss-Maffei engine, modified to get more horsepower. Some of the accessories have been rearranged to make the engine easier to service.

The crankcase fits down between chassis frame members and the V arrangement of the cylinders extends over the frame channels without cramping. The crankshaft and transmission are lined up with the differential so that the universal joints in the drive shaft have minimum angularity.

The 3-main-bearing crankshaft weighs 155 lb with 4 in. diameter main journals and 3 in. diameter crankpins. The overlap between the main journals and the crankpins is 15/16 in. This contributes greatly to the stiffness of the shaft. The 2-cycle, 90 deg V cylinder arrangement produces an inherently well balanced crankshaft, connecting rod, and piston system. The crankshaft is counterbalanced for the rotating masses of the crankpin and the large end of the connecting rod and all vertical reciprocat-

E. C. Ginn, Continental Motors Corp.

Based on paper "Meeting Present-day Power Requirements with a V-8 Diesel" presented at SAE Golden Anniversary Diesel Engine Meeting, St. Louis, Nov. 3, 1955.

THE CONTINENTAL V-8 diesel is an 8-cylinder, naturally aspirated, 603 cu in. engine weighing 1525 lb. Friction losses are low, giving it high mechanical efficiency. It has a rugged structure designed along conventional lines.

Rods are fitted side by side on a common journal with individual bearings. Large ends of the rods are tin-plated to permit close fitting without danger of scuffing.

All oil passages are drilled—there are no oil lines. Heads are identical. Tappet construction is simple with guides integral with the block. Oil pump is submerged; the oil screen is floating.

A simple injection pump is driven vertically from the camshaft and nestles in the V of the cylinders towards the rear of the engine. Another vertical drive is provided near the front of the V for any other accessory of limited power consumption at half engine speed.

Fig. 1 is a view of the crank piston and rod assembly. The crank is conventional and fully counterweighted. The two end counterweights have been reduced in width somewhat and the difference in counterweighing is made up in the pulley in front and in a stamped plate attached to the flywheel in the rear. By redistributing counterweights this way the engine is shortened 1¾ in., saving about 35 lb.

Pistons are aluminum. Each has five rings and is constructed to have a minimum of thermal and mechanical distortion. Skirt is scalloped to reduce height of the engine block and still leave a long gliding surface for piston stability.

Rod journals have lightening holes. Crank material is SAE-1045 and is Tocco-hardened. Rods are particularly sturdy. They seat well and are broached with a torque and groove construction for maximum cap-to-blade rigidity.

Fig. 2 shows the undersection of the cylinder block. Note the cantilever construction of the bearing caps and the bolting. The lower crankcase is extremely rigid, yet simple. Strength is obtained by shape rather than surplus material.

Fig. 3 shows the upper block. Note the bolting pattern for the head. Rigid clamping of the gasket is obtained without measurable bore distortion. The top deck is unusually heavy and strong. The case is strong, clean, and simple, and easy to cast.

Fig. 4 is a diagram of the oil system. The gear

CONTINUED ON PAGE 34

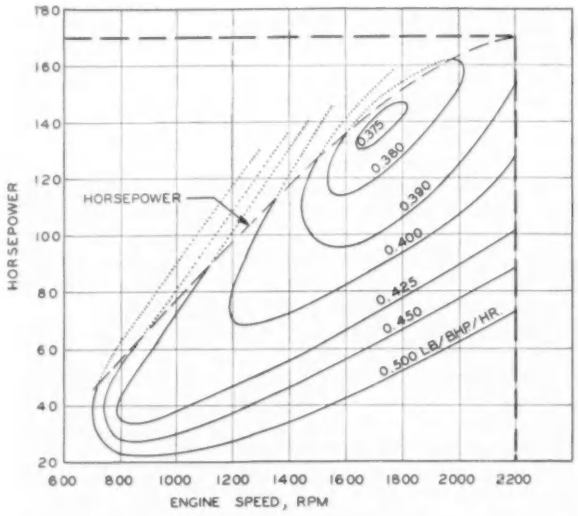


Fig. 1—White V-106 consumes least fuel in the most used speed range. Diagonal dashed line is the rated maximum load within the speed range of the engine.

ing forces. Only a very small horizontal component remains, which is easily absorbed in the engine mounting.

The crankshaft and connecting rod oil system is completely pressure fed. Oil is supplied through drilled holes in the crankshaft to the crankpins which, in turn, feed oil through rifle-drilled connecting rods to the piston pins and the spray jet. Precision bearing shells are used for both main bearing and crankpins. The thrust is taken by thrust washers at the center main bearing.

The crankcase is a single casting which carries the crankshaft and forms part of the air box on which the individual cylinders are mounted. The front end of the crankcase is machined for mounting of the gear train which drives the blower and injection pump. Various drilled holes serve as lubricating oil distribution passages. The water inlet manifolds are cast into the crankcase.

The piston and connecting rod assembly is shown in Fig. 2. The connecting rod has an H-beam section for high strength and low weight. It is rifle-drilled for lubrication of the piston pins with a spray jet at the upper end. The piston pin is mounted in spiral groove bushings in the small end of the connecting rod and also the piston. It is full floating and retained by plugs mounted in the piston at the end of the piston pin. The piston is pearlitic nodular cast iron. It has three Keystone compression rings and two oil rings.

Each cylinder is an individual casting with an integral water jacket. Rubber o rings seal the water passage joints with the crankcase. There are three exhaust ports flanked by three air inlet ports on each side. All the air inlet ports are directed upward from the exhaust ports to displace the spent gases and minimize short circuiting the fresh air to the exhaust ports. The exhaust passages from the ports are large, assuring free flow of the exhaust gases. The individual box section cylinder heads are shown

Fig. 2—Piston and connecting rod assembly. Spray oil jet at the upper end lubricates and cools piston.

in Fig. 3 with water outlet piping and injection nozzle.

The oil pump, shown in an exploded view, Fig. 4, has specially-shaped pumping teeth. It is driven directly from the front end of the crankshaft by an involute spline. An oil pan with Floto oil screen carries 14 qt of oil.

Exhaust manifolds are large to minimize exhaust pulse interference and give maximum clearance for the injection system in the V at the top of the engine.

The water pump is conventional except for double outlets, one for each bank of cylinders.

The injection nozzles are of the differential type and both American Bosch and RoosaMaster injection pumps are used.

The smaller number of parts of the V-106 engine

obviously influence the cost of labor and materials in maintenance and adjustments. This engine is being built in both 4-cylinder and 6-cylinder versions. The 8-cylinder engine will complete the family which will have interchangeable wearing parts. The present 6-cylinder engine extends the power range up to 255 hp.

For complete paper on which this abridgment is based write SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.

Vital Statistics

Specific weight	6.4 lb/hp
Bore	5-⅛ in.
Stroke	5-⅛ in.
Piston speed	1879 fpm @ 2200 rpm
Displacement	106 cu in. per cylinder
Bmep	72 psi @ 2200 rpm (4-cylinder)
Horsepower	170 bhp @ 2200 rpm (4-cylinder)

Discussion

Q. What kind of spray pattern is used?
A. The nozzle tip has six 0.006 in. diameter holes having an included angle of 140 deg. It is aimed at the lower lip of the combustion chamber.

Q. How is the cylinder lubricated above the ports?
A. All of the lubricant is carried by the piston outside diameter.

Q. Do you use a cast crankshaft?
A. The shaft is an SAE 4340 forging either Tocco or nitride hardened.

Q. What kind of bearings are used?
A. Either copper lead or aluminum on steel.

Q. Why did you put the combustion chamber in the cylinder head?
A. To keep the piston crown simple.

Q. Why is there an insert of some alloy in the rim of the combustion chamber?
A. It helps limit an erosion problem which we had originally.

CONTINUED ON NEXT PAGE

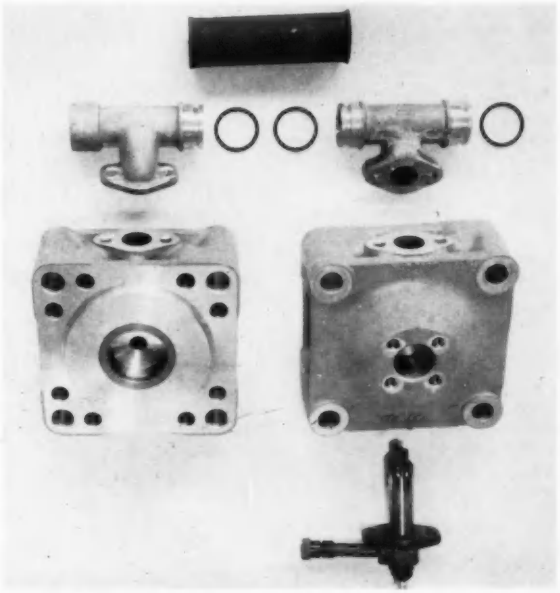


Fig. 3—Cylinder heads and water outlet pipes and an injection nozzle. Cylinder heads are separate castings with an integral water jacket.

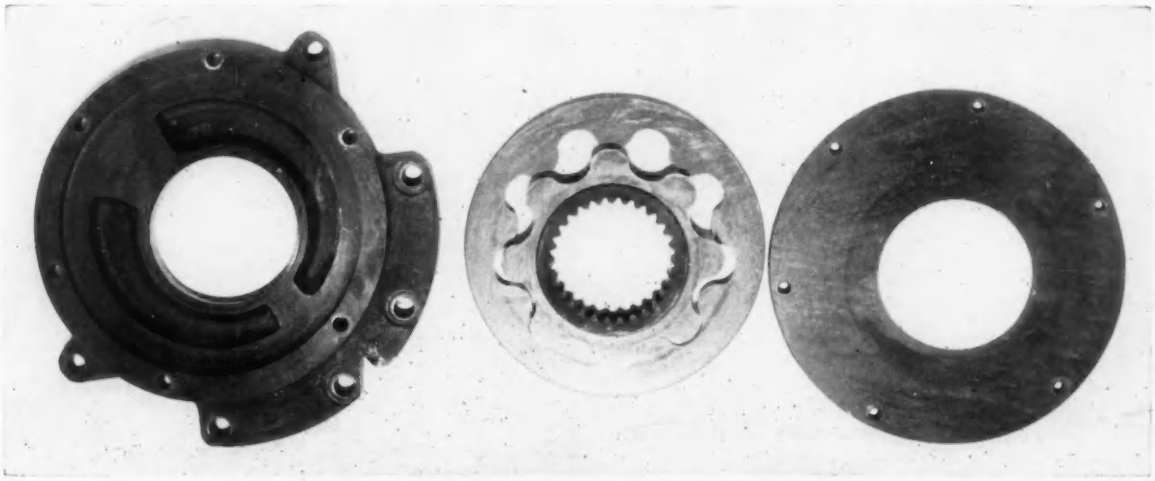


Fig. 4—Exploded view of V-106 oil pump with specially shaped pumping teeth.

Q. Do you use #1 or #2 fuel to run your engines?
A. We are running on #2, however we have run on #1 with comparable results.

Q. What have you done to eliminate cylinder distortion due to the difference between intake and exhaust port temperatures?
A. The area at the port band is relieved, however we have seen no indications of piston scoring due to this difference.

Q. Why do you use individual single cylinder heads? Don't you lose crankshaft length and rigidity?
A. The only way a small organization can cover a wide power range with a low tooling cost is to make individual cylinder heads. Yes, we do sacrifice length and rigidity.

Q. What is your lube oil consumption?
A. High. The original German engine used an exterior lubricating device which we thought might be profitably eliminated. This does improve the lube oil consumption but not enough.

Q. Is there a liner for the cylinder?
A. The cylinder head and liner are integrally cast. The casting is simple, small, and cheap.

Q. Does the engine require an oil cooler?
A. Yes. It is located at the front of the crankcase.

Q. Is part of the combustion chamber in the cylinder head?
A. No. Our performance to date has been satisfactory and we feel that a flat piston crown improves ring cooling and life.

By Continental . . . continued from page 31

type, submerged oil pump delivers through a cored passage to a gallery line. The oil relief valve bypasses all oil beyond the actual engine requirement back to the suction side of the pump. This, at operating speeds, is about 2/3 of the pump capacity. This reserve insures adequate oil pressure at idling on a worn engine. The remaining oil then passes through a cooler which also acts as a warmer when the oil temperature is below that of the engine water and thence is distributed to the engine parts. A pressure differential bypass insures a flow of oil to the bearings at all times, even if the oil in the cooler is congealed.

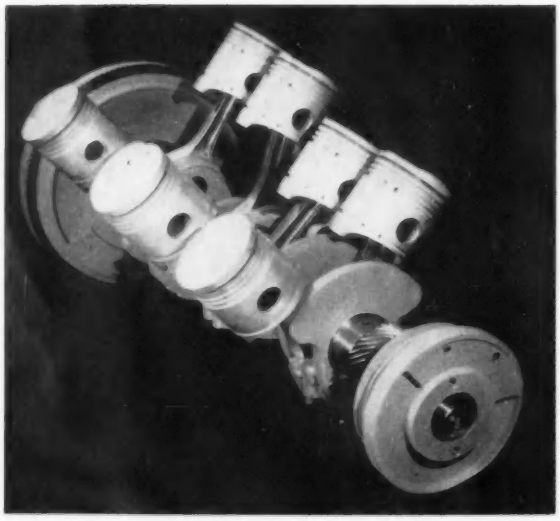


Fig. 1—Crank, piston, and rod assembly. The two end counterweights are somewhat thinner than usual but this is made up in the pulley in front and in a stamped plate attached to the flywheel in the rear.

Oil to the overheads is metered through the intermediate cam journals and, by registering once every other engine revolution, admits oil to the hollow rocker shaft. This method restricts the flow of oil but permits application of full engine pressure to large passages and avoids plugging of restriction otherwise necessary to reduce total flow.

The water pump has a double stripper so that the same flow will go to each block, even though there should be a difference in the flow restrictions on each side. Passages are large, and the pump flow is 199 gpm at 3000 rpm. This means that at this speed the entire water capacity of the block circulates through the engine each 2.9 sec. In addition, it is directed to areas of heat concentration to maintain a continual scrubbing action. Cooling water, with the engine under full load, varies in the cylinder head only plus or minus 3 deg. Heat rejection to the water is low (about 32 btu/bhp at full load).

A typical indicator card is shown in Fig. 5. This card was taken at 2000 rpm, full load. The absence of shock and the low pressure values make possible a relatively light-weight structure.

This is accomplished by using an open type combustion chamber with a shock absorbing (or time delay) means. (See Fig. 6.) In operation a very coarse stream of fuel under moderate pressure is squirted across the combustion chamber at the proper time. Fig. 7 illustrates what takes place and how it registers on the indicator card.

In the upper left corner, at "A", injection is just starting. Note that the fringe of fuel around the

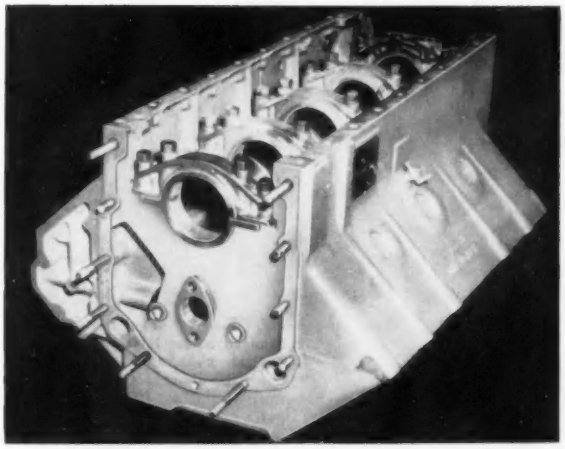


Fig. 2—Undersection of the cylinder block. Note the cantilever construction of the bearing caps and the bolting. All main bearings are line-reamed from one reaming bar in one operation to assure perfect alignment.

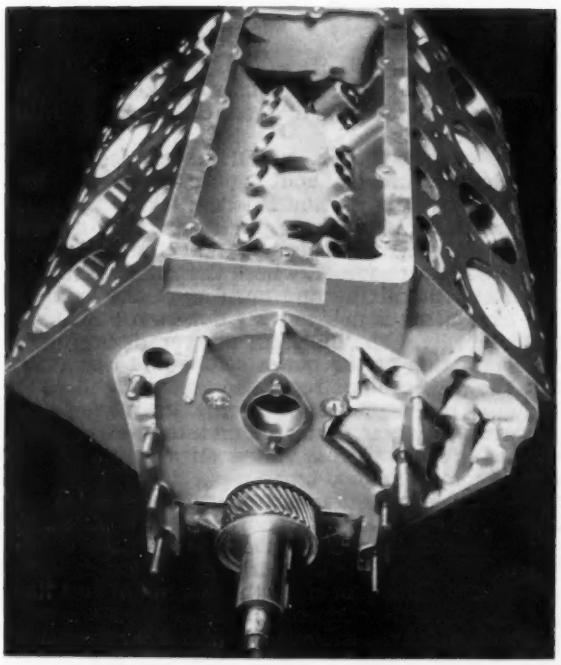


Fig. 3—Top deck of the block is unusually heavy and strong. Note the bolting pattern for the head.

Vital Statistics

Weight:	1525 lb
Stroke:	4-¼ in.
Bore:	4-¾ in.
Piston speed:	2000 fpm @ 2800 rpm
Displacement:	603 cu in.

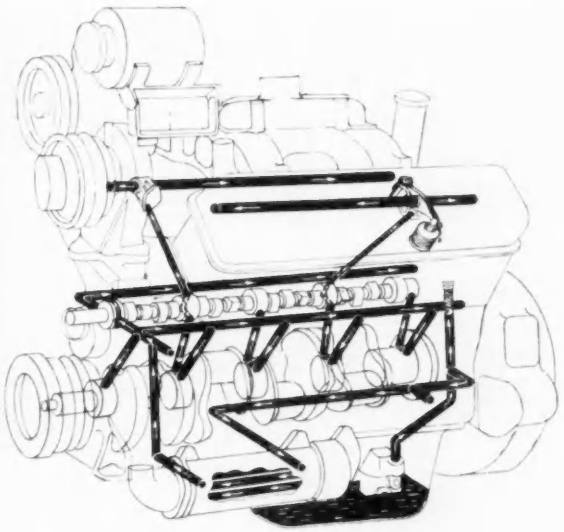


Fig. 4—Lubrication system of the V-diesel. Gear type submerged pump delivers oil through scored passage to a gallery line thence to the rest of the system.

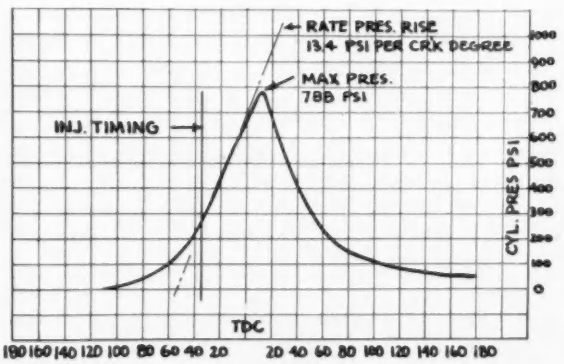


Fig. 5—Indicator card taken at 2000 rpm and full load. Low pressure and absence of shock makes possible a relatively lightweight structure.

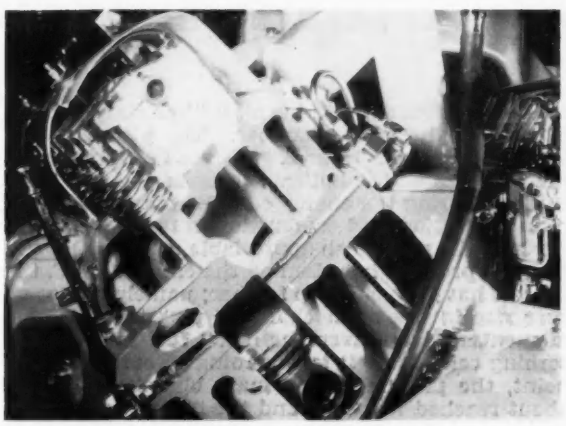


Fig. 6—Open type combustion chamber has a shock-absorbing, time delay cell on one side and a nozzle on the other.

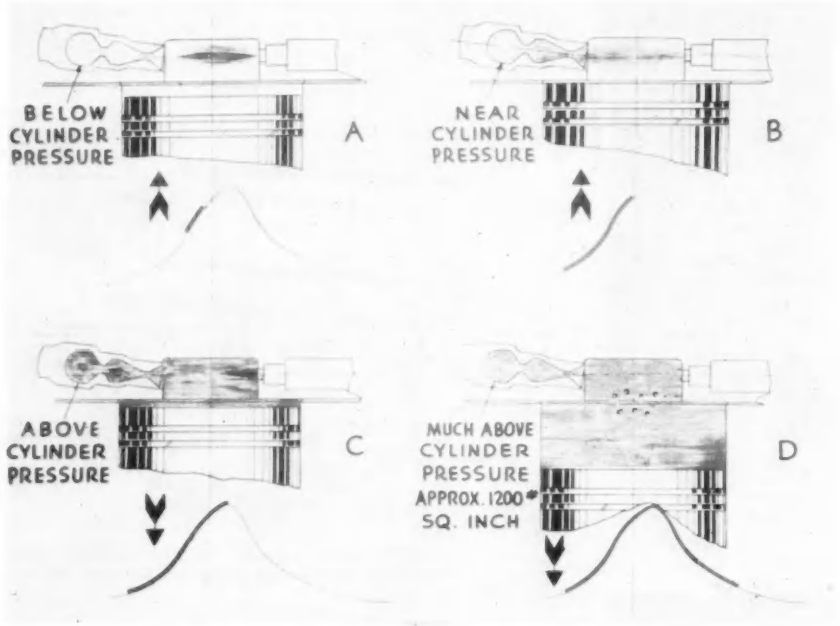


Fig. 7—(A) Fuel is squirted across the combustion chamber. (B) Some of it enters the energy shell. (C) It burns and discharges into the cylinder. (D) High turbulence helps complete mixture and burning of fuel.

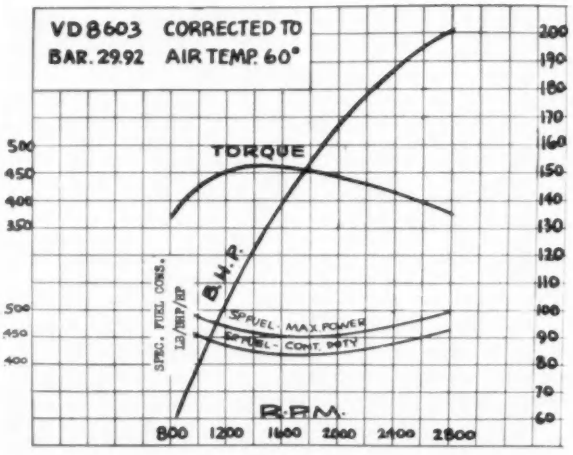


Fig. 8—Performance characteristics of the Continental V-8 diesel.

solid core is starting to burn and has started combustion in the main chamber. The piston is still traveling upward. Note also the start of combustion pressure rise on the indicator diagram. At "B", the fuel is entering the energy cell, the nozzle has completed injection, and combustion in the main chamber has advanced to an appreciable degree. Observe how the pressure has risen on the card. At "C", the process has gone one step farther; namely, the pressure rise in the main chamber, plus the injection momentum, has driven the liquid fuel into the absorbing cell, where it is beginning to burn. At this point, the presure in the main chamber has just about reached its peak; and the piston's downward displacement is beginning to be a major factor in cylinder pressure reduction. However, now that burning has started in the absorbing cell, it is generating a little pressure diagram of its own, and this of no mean value.

In "D", we see the energy cell has reached its peak value in pressure of about 1200 psi and, with the large pressure differential between it and the main chamber, is rapidly discharging its mixture of burning gas and raw fuel through the calibrated orifice into the main chamber, where the high turbulence completes the mixing and burning of the fuel and air. The piston is now moving downward at an appreciable rate. The indicator diagram is now nearing completion of the power stroke and has shown that the pressure has remained below 800 lb. It is through this sequence of events that we reduce shock to the engine parts and maintain low cylinder pressures for low stress values on operating parts, and yet maintain good bmep.

We effect a pressure controlled time delay somewhat similar to the splitting of an electric phase.

It is as though we had a pressure regulator on the cylinder. (When the pressure rises in the cylinder, a regulator reduces or stops the amount of fuel flow, and thus arrests or controls pressure rise.)

If we could make the injector pressure responsible, we would accomplish the same thing in a mechanical manner; but that is difficult. It is much easier and simpler to let the engine fix its own values through the gas pressure differential method. It is this characteristic which prompts the term "Cushioned Power."

As shown in Fig. 8, this engine has a broad torque curve and a good speed range. It is a flexible engine, very quiet and it burns very cleanly. Automatic injection timing contributes materially to the broad operating range. Supercharging can increase the speed range further.

For complete paper on which this article is based write SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.

R. S. Frank and W. J. Lux, Caterpillar Tractor Co.

Based on paper "A Billion Engine Hours on Aluminum Bearings" presented at SAE Annual Meeting, Detroit, Jan. 9, 1956.

Steel Backed Aluminum Bearings . . .

. . . provide excellent high load and high speed operation in diesel engines.

STEEL backed aluminum bearings have properties which provide superior high speed and high load performance in diesel engines. The combination of steel and aluminum gives the advantages of each; hence, a better bearing.

The steel backed aluminum bearing appears to have removed the two major limitations of solid aluminum bearings. That is, a tendency, at high speeds and corresponding high temperatures and loads, for the thinner walled connecting rod to lose its crush and become loose in the bore. And, a tendency to fail in fatigue, peculiarly, under high load conditions. Such failures, which are rare and caused by extreme conditions, result in cracked bearings, as shown in Fig. 1.

The steel backed aluminum bearing has the advantages of a high strength material with a larger modulus of elasticity than that of solid aluminum. It retains its crush at higher temperatures than solid aluminum. In addition, the steel backing provides us with a material having a coefficient of expansion about the same as the cylinder block or connecting rod material.

Many failures and difficulties were met and overcome before a successful steel backed aluminum bearing was developed. As an example of one of the difficult problems of manufacturing these bearings, forming the flanged thrust-carrying main bearings stands out. (See Fig. 2.) We wanted to maintain interchangeability between our solid aluminum alloy bearings and the newer steel backed ones. So we tried to maintain the same wall thicknesses.

Since the solid aluminum bearing had relatively thick walls, flanging of such steel sections without rupture of the bond or splitting of the steel presented a problem. Tests revealed, however, that the bond was extremely ductile and would stand all of

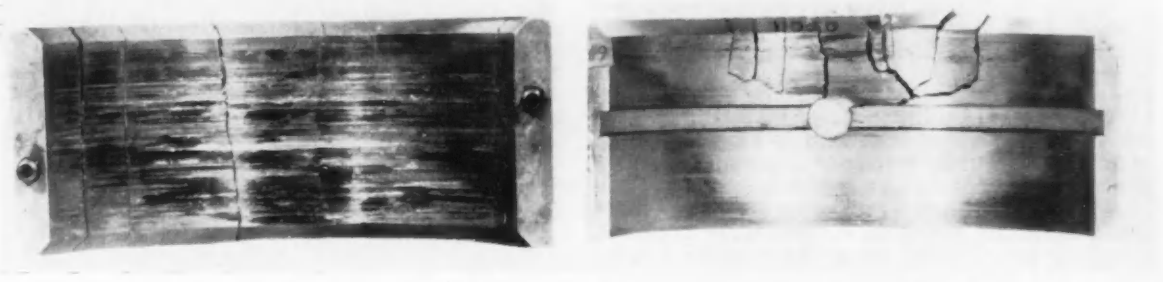


Fig. 1—Here's what happened to a solid aluminum bearing when subjected to high load conditions. Cracking of the bearing was caused by metal fatigue.

Fig. 2—Flanged thrust-carrying main bearings made of aluminum with steel backing were difficult to manufacture because of their relatively thick walls.

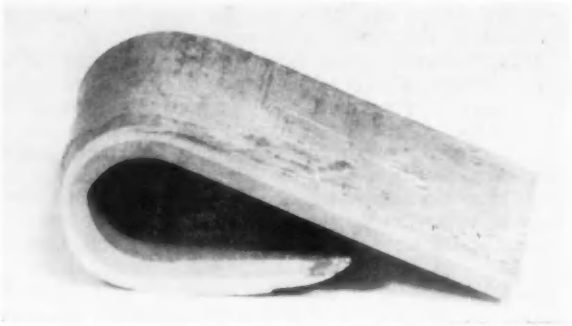


Fig. 3—Tests revealed that the aluminum-to-steel bond was extremely ductile.

the stress imposed on it in flanging without failure. Fig. 3 shows the ductility of the aluminum-to-steel bond.

The aluminum itself seemed to stretch readily, but the steel sometimes split at the parting line as shown in Fig. 4. We found that the ratio of wall thickness to diameter was such that an economical flanged bearing could not be made in some sizes. So we turned to thinner walls to facilitate manufacturing and keep down costs. This destroyed the advantage of interchangeability with solid aluminum bearings. But it was considered worth this disadvantage.

On the steel backed bearings, we use Alcoa XB80S aluminum alloy, which is of essentially the same chemistry as the Alcoa 750 or Bohn MB7 materials used in our solid aluminum bearings. As expected, we found the same good bearing properties in the new bearings as we had in the solid aluminum bear-

Fig. 4—The aluminum stretched readily in the flanging process but the steel sometimes split at the parting line.

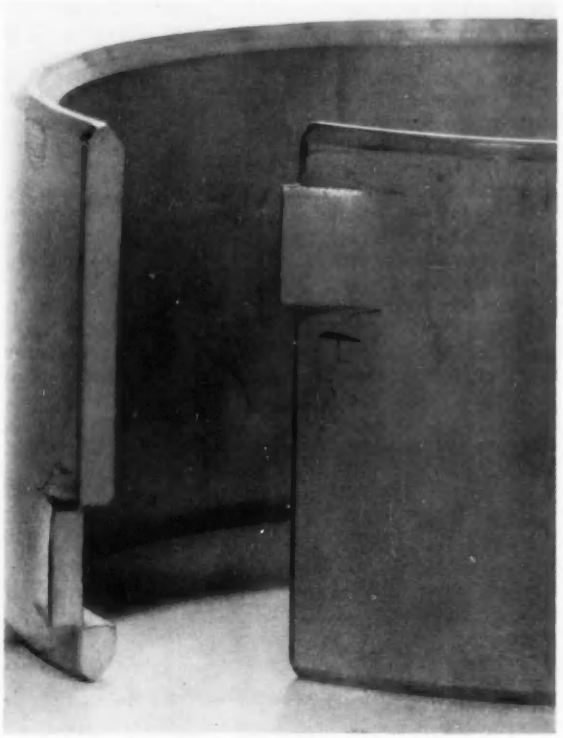


Fig. 5—Steel backing allows simple and expensive bearing locating designs. The tabs shown on the bearing above provide a simple method of preventing both rotary and axial motion of the bearing shell.

ings. In addition, the two major shortcomings—looseness and fatigue failures—of the solid aluminum bearings were eliminated. Also, the bearing clearances could be reduced 37% over those with solid aluminum.

On steel backed aluminum bearings, we use clearances of 0.0012 in. per in. of journal diameter. To engine manufacturers who consider such clearances excessive, we suggest eccentric bearing walls which provide a closer clearance in the vertical plane. We are interested in reducing the large amounts of oil which flow through our bearings because such reductions offer advantages in smaller oil pumps and in filter design. Eccentric bearing walls are being studied for reducing oil flow on our engines for this reason.

Because wear on the aluminum bearing material is negligible, operation below a 5000 psi fatigue stress value gives us a bearing without a life limit. The steel backing makes the bearing less sensitive to high oil temperatures. Where 215 F is the maximum oil temperature that can safely be used with solid aluminum bearings, steel backed aluminum bearings may be safely run at oil temperatures up to 250 F.

Recently, we examined a set of steel backed aluminum bearings with 29,000 hr of service. Wear was negligible and there were no surface defects which would prevent the bearings from being reassembled for further use.

Another advantage with steel backing is that it allows simpler and less expensive bearing locating designs. Dowels can be eliminated and tabs, as shown in Fig. 5, substituted to provide a simple method of preventing both rotary and axial motion of the bearing shell.

We are pleased with our success with steel backed aluminum, and to date, we haven't found any other material that fully satisfies our requirements. We know there are still factors of aluminum bearing design which can be improved and we are continuing to concentrate our efforts to develop these improvements.

Cost reduction is a primary objective since lower cost will make steel backed aluminum bearings more adaptable to small, low cost engines. Much work can and will certainly be done in this area not only by our company but by the bearing manufacturers.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

Truck Cabs . . .

. . . could be a credit to their vehicles. Here are suggestions for better design and construction of this much neglected component.

Based on paper by **B. C. Harris,** The White Motor Co.

CABS age more rapidly than the rest of the vehicle. Long before the mechanical units are in a state of poor maintenance, the cab can come to look and sound like an ill-used tin can. This isn't necessary. The cab will profit from being viewed as an engineering entity rather than by following the practices and using the materials generally employed in passenger car body construction.

Aluminum and fiber-reinforced plastics might be desirable materials for cabs. Both are light and both resist corrosion. Their costs are high and there are problems of fabrication, but these might be worked out in time.

Better mountings could increase cab life. The task is to anchor the cab to the frame at points where it will be least affected by racking and vibration. Neutral points are to be found on the frame somewhere near the back of the cab and midway between the rails at the extreme front of the frame. With two mounts in the rear and one at the front, a three-point mounting could be achieved that would be free from the scissor-like action of the frame.

Window regulators and remote controls of door locks should be made stronger. The glass retaining channel should be made of stainless steel to prevent rust, and all moving parts should be bushed or made to avoid excessive wear. Because the right-hand window is likely to be out of the driver's reach, it should be made to operate remotely.

Following aircraft practice, doors should be pulled shut and snugged against the weather seal by a cam type lock. This is better than a door that locks by slamming. It would also permit use of heavier rubber seals.

Ventilators should be well sealed against air leakage, and there should be adequate insulation against engine heat. A moderate amount of trim would reduce noise and make it easier to control cab temperatures in summer and winter.

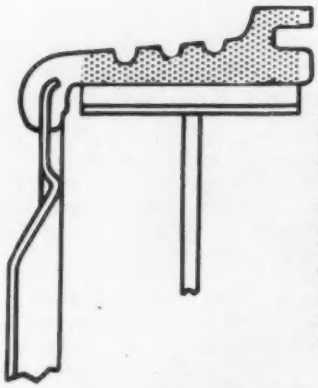
A good, high-output, quiet, fresh-air heater is a must. It should be positioned to serve the driver.

It should be possible for the driver to change the seat angle and height without using an instruction book.

A windshield of clear flat glass, large enough to afford unhampered vision, is hard to beat. Curved glass on trucks is an absurdity. It does not give perfect optics and it picks up reflections at night.

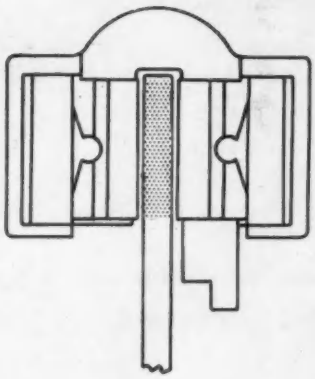
These suggested improvements would make a lighter, more durable, and more comfortable cab, and one with more driver appeal. And the virtues will pay off in larger payloads and better driver relations. (Paper "Engineering Considerations for Truck Cabs" was presented at SAE Passenger Car Body & Materials Meeting, Detroit, March 7, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

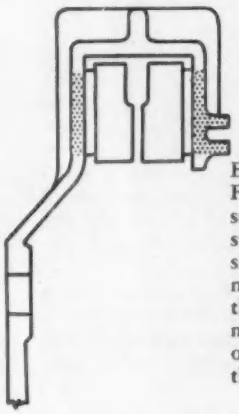
Basic Brakes



SHOE BRAKE—(One rubbing surface) Friction-lined shoes expand outward against the inside cylindrical surface of the brake drum. Friction between the primary shoe and the drum rotates the shoe sufficiently to bring the secondary shoe into contact with the drum. Thus braking effect is multiplied. However, when heat builds up the drums tend to expand away from the shoes, causing loss of pedal reserve, loss of friction in the brake lining material, and brake fade.

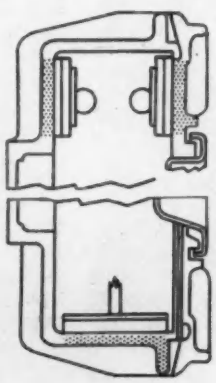
CALIPER DISC BRAKE—(Two rubbing surfaces) Rotating disc is clamped between two friction-lined pads. A comparatively small area of lining is swept by a large area of disc surface. This dissipates heat quickly. There are no drum or disc expansion problems either. However, the exposed disc area is susceptible to clogging by mud and grit and attack by salt air. This type of brake has been used quite successfully in relatively small quantities on sports cars, particularly in England.





ENCLOSED DISC BRAKE—(Two rubbing surfaces) Friction pads expand outward against the inside end surfaces of a brake drum. This brake provides a large swept area, it dissipates heat quickly, and can be designed with a self energizing mechanism which avoids need of excessive pedal pressure. Both mechanical and thermal distortion can be held to a minimum. Automatic adjustment is feasible. Radial ribs between the operating faces act as impellers forcing cooling air through a completely enclosed path.

DISC SERVO BRAKE—(Three rubbing surfaces) There are two friction pads which expand against the flat end surfaces of the drum, as in the disc brake, and an arc-shaped shoe which expands against the inside cylindrical surface of the drum, as in a shoe brake. Friction force between the pads and the drum is transmitted through linkage so as to press the shoe against the drum. Much of the force for pressing the pads against the surface is furnished by the self-energizing ball-and-ramp mechanism. Pads and shoes are small compared to the large swept area of the drum.



New Brake

The Authors

This article is based on the following papers and discussion presented at the symposium "New Passenger Car Brake Developments" during the SAE National Passenger Car, Body, and Materials Meeting, Detroit, March 6, 1956.

Fade and Stability in Automotive Brakes

J. W. Kinchin, Girling, Ltd.

Combining the Features of Disc and Shoe Brakes

T. H. Thomas, Bendix Products Division, Bendix Aviation Corp.

The Budd Automotive Disc Brake

D. P. Dyer and C. L. Eksergian, The Budd Co.

The New Studebaker Flared Cross-Rib Drum Brake

W. B. Love and D. E. Hobson, Studebaker-Packard Corp.

Discussion:

J. T. Ball, Chrysler Corp.

S. G. Tilden, The Permafuse Corp.

H. P. Hayes, Ford Motor Co.

H. M. T. Harris, American Brake Shoe Co.

Developments Show Progress In The . . .

FIGHT AGAINST FADE

FOR modern high-speed automobiles that require bigger, better brakes in smaller, hotter brake spaces, brake fade is becoming an increasing problem. Several recent developments, however, offer possible approaches to solving this problem.

Regardless of brake type, it appears that the prime requisite a brake must have during a single stop is sufficient drum mass to absorb the generated heat. For prolonged braking, rapid heat dissipation is more important.

Generally brake designers have not had too much difficulty designing brakes to handle the heat generated during one high-speed stop. (Aircraft brakes are a good example.) However, for successive high-speed stops, or during prolonged braking while driving down a long hill, heat build-up has caused lining fade, drum distortion, brake fluid vapor lock, and stability problems.

Here is how several brake manufacturers have attempted to alleviate these difficulties:

Bendix Products' Disc-Servo Brake

Bendix Products has combined the best features of disc and shoe brakes in one Disc-Servo brake. It has three friction surfaces, two pads, and a shoe.

The brake drum is similar to that in the enclosed disc brake: the flat end surfaces are friction surfaces. Too, like in the shoe brake, the cylindrical surface is also a friction surface.

Two friction pads are forced outward by a hydraulic cylinder to bear against the flat end-surfaces of the drum.

A ball-and-ramp self-energizing mechanism increases the pressure of the pads against the drum.

As the pads move around a little with the drum, the motion is transmitted through linkage so as to press the shoe against the drum. The work of braking is about equally divided between the pads and the drum. There is no direct connection between the foot pedal and the brake shoe. Thus some of the momentum of the vehicle is used to brake the vehicle.

Fig. 1 shows the Disc-Servo brake. The drum protects the pads, arc-shaped shoe, and hydraulic mechanism of the brake. Cooling fins on the drum help dissipate heat.

In Fig. 2 the major parts of the brake are labeled. Not shown in the illustration are the wheel cylinder, located outside the brake itself, and levers which connect the wheel cylinder piston to the pads. As the wheel cylinder piston force is applied to the left ends of the pads, the pads are spread apart. Their left-hand ends therefore contact the disc surfaces of the housing and the pads are carried around slightly with these surfaces.

A ball-and-ramp arrangement interconnects the pads with the upper end of the relay lever so that, as the pads move in either direction the right-hand ends of the pads are pressed against the surfaces of the drum at both ends, and consequently along their entire length. Also, a force equivalent to the braking force developed by the pads is applied to the upper end of the relay lever, tending to make it revolve counterclockwise about point P which is a stationary pivot.

The counterclockwise motion causes the adjusting link to exert a downward force against the right hand end of the shoe. This presses the shoe into the drum with a force proportional to the amount of braking force being exerted by the pads.

The shoe works as a trailing shoe. Trailing shoes are relatively unaffected by changes in lining coefficient, but they require application of a considerable force, compared with leading shoes. This large force usually must be supplied from a foot operated brake pedal either by considerable pressure or pedal travel, unless a power assist is used.

In the Disc-Servo brake, however, the force delivered to the trailing shoe by the pads is multiplied (about three times) by the relay lever. Both the force and the distance components of the work re-

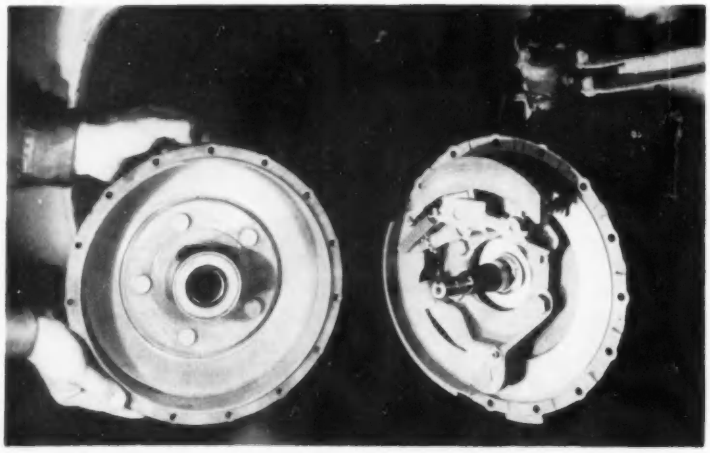


Fig. 1—The Disc-Servo brake has a finned drum which protects the braking mechanism from dirt and supplies the rubbing surfaces against which two pads and a shoe bear.

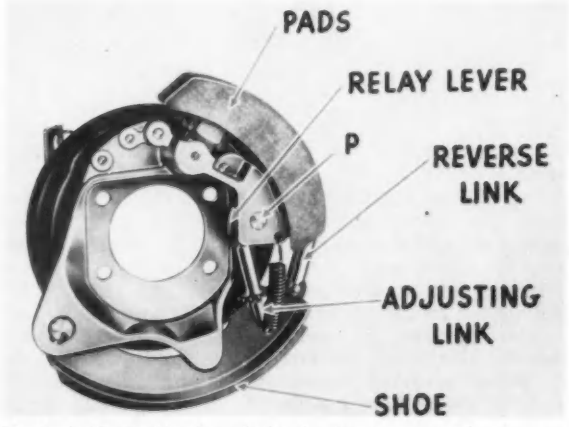


Fig. 2—Inside the Disc-Servo brake the shoe is actuated by the servo effect of drum rotation and friction. The pads, which are part way around with the drum, rotate the relay lever around the pivot P. This causes the adjusting link to press the shoe against the drum.

quired to actuate the shoe come from the work which must be done by the pads anyway to decelerate the car. Actuation of the shoe, which does about 55% of the braking, is obtained entirely from the servo effect of drum rotation and friction, at no expense to pedal pressure or pedal travel.

For reverse braking, the pads are carried in a clockwise direction with the drum, thereby rotating the relay lever clockwise about point P. The shoe acts as a leading shoe. To compensate for the action of the shoe as a leading shoe, and to maintain proper work distribution between the pads and the shoe, the lever ratio for reverse braking is about 1/1 instead of 3/1. The overall effectiveness is essentially the same for either forward or reverse braking.

Tests of the Disc-Servo brake indicate that after 17 or 18 consecutive stops temperature build-up in the brake housing levels off at about 500 F. That's about 200 deg lower than temperatures built up in a conventional 11-in. shoe brake. This, of course, contributes to fade resistance and helps the relatively small segments of brake lining to stand up longer.

Studebaker-Packard's Flared Brake Drum

Studebaker-Packard combats brake fade by using a heavy flared, cross-ribbed drum. The flare increases air flow across the drum, and the ribs provide additional surface area to aid heat dissipation.

The new drum, developed and supplied to Studebaker by the Budd Co., is shown in Fig. 3. It has a cast iron drum ring and a steel back. The flared extension is added to the conventional rib at the mouth or seal edge of the drum. The flare protrudes over the brake backing plate and diverts the air stream underneath the car to flow across the drum. The cross ribs blend into the flare for strength and conduct heat from the braking surface to the flare. The drum is used on the self-centering, self-energizing brake which has been used by Studebaker since 1954.

Tests have shown that the flared cross-rib drum builds up temperatures about 44% less than a standard drum during a series of 10 stops from 55 mph at 1 min intervals and 10 ft per sec^2 deceleration. The heat dissipates faster, too.

Fig. 4 shows the improvement in brake fade performance provided by the flared cross-rib drum over a standard drum. On the twelfth stop the performance of the car with the flared cross-rib drum is still above its initial performance. With the standard drum fade occurs rapidly after the fourth stop. Extended fade tests of the new drum show it capable of at least 24 stops without an appreciable loss in performance, erratic behavior, or damage to the linings.

The Budd Co.'s Caliper Disc Brake

The Budd Co., has a caliper type disc brake for automobiles similar in principle to its railway brake. Impeller-type ribs between the operating faces force air over the cooling surfaces. Thus heat is dissipated faster, operating surfaces are kept cooler, and fade is reduced.

This brake, shown in Fig. 5, has a single disc, with two faces. A short arcuate shoe bears against these surfaces. In braking, heat is generated very rapidly, creating a steep temperature gradient between the friction surfaces and the interior of the disc. Therefore heat flows very rapidly into the disc. (If for

some reason it does not, surface temperatures rise very rapidly causing distortion and checks.) The single disc with the short arcuate shoe is designed specially to facilitate this flow, thereby accounting for the high peak power capabilities of the brake. The shorter the shoe, the less time is available per revolution for doing the assigned work, therefore the rate of heat generation is higher. Consequently the shorter the shoe, the steeper the temperature gradient, and the faster the heat flow into the disc interior. Also, the shorter the shoe, the longer the period of rest per revolution and, therefore, the greater the time available for heat to flow into the disc. Thus maximum surface temperature is lowered and longer lining life is achieved.

The greater the mass of the disc the more heat it can absorb. Accordingly it is an inexpensive substitute for blowers, large surfaces, and other means of trying to provide a rate of cooling equal to that of heat generation.

During steady braking in which heat is generated over a period of time, the storage capacity of the disc merely slows down temperature rise for a while. Eventually equilibrium is reached. So, although a large mass is advantageous in smoothing out peak heat loads, a thin wall is better during continuous brake application for dissipating heat to the atmosphere quickly.

To help heat dissipation, ribs or vanes are placed between the disc surfaces. Besides increasing the surface area these vanes force cooling air through the brake achieving exceptionally high rates of dissipation under relatively low temperature heads. This gives the brake a large continuous power capacity, with less fade and lining wear.

To eliminate vapor lock the Budd disc brake has its wheel cylinders outside of the brake in the slipstream of the passing air.

It is adaptable to power brakes with or without energizing. Because of the freedom from drum distortion, shoe flexing, and variation in self-energizing due to lining wear and brake adjustments, a higher ratio of power assist can be used with perfect controlability.

At an average speed of 20 mph the Budd disc brake can absorb about 25% more heat than a conventional drum brake. At 40 mph it has a 50% greater thermal capacity. Above 60 mph the disc brake's great reserve capacity, freedom from fade, and dependability is fully realized. At these high speeds the disc brake's advantages of light weight, durability, and capacity to absorb large peak and continuous power, long lining life, and dependability far outweigh its increased cost due to more exacting tolerances, and its relatively expensive cored disc casting.

European Brakes

The fundamental difference between the European and the American approach to braking is generally European vehicles do not use brakes with a high self-energizing factor. The basic brake in Europe is either a two-leading-shoe front brake and a leading and trailing shoe rear brake, or a leading and trailing shoe front and rear brake.

Girling, Ltd. attempts to design a brake which has a minimum change of torque per change in coefficient of friction. A slight reduction of coefficient

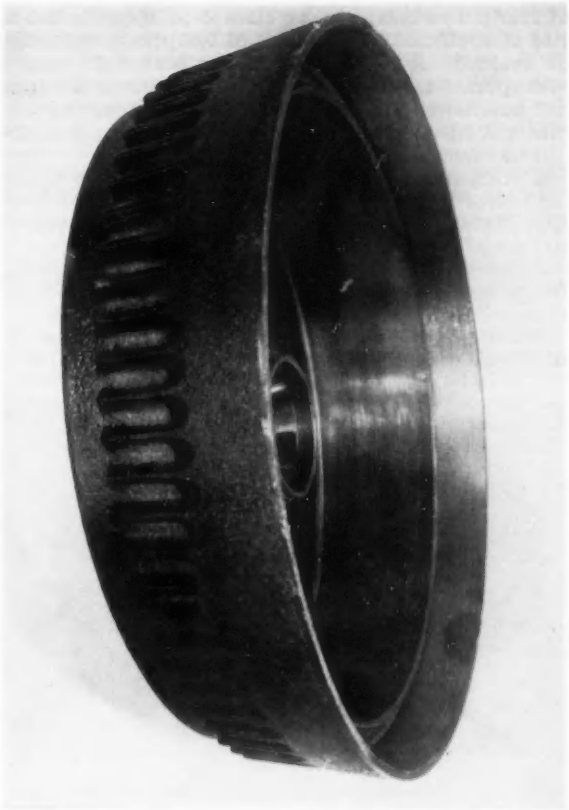


Fig. 3—Flared-rib drum, made by The Budd Co. for Studebaker-Packard, provides additional surface area by ribs and deflects airflow onto the brake drum by means of the flared extension.

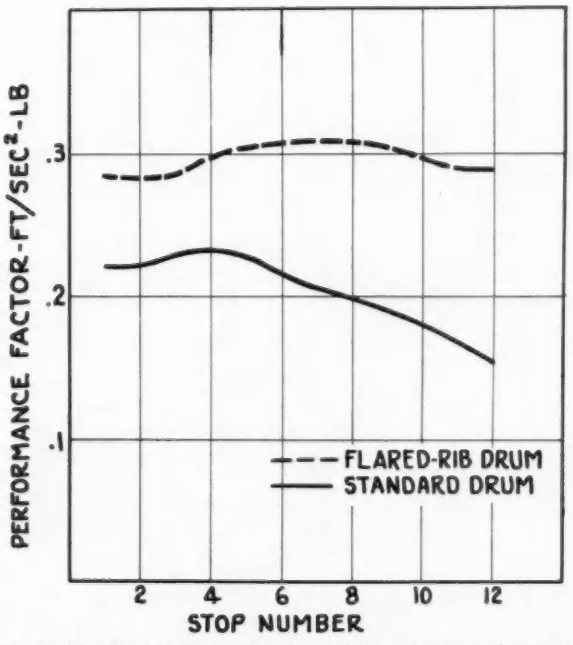


Fig. 4—The flared-rim drum gives better fade performance characteristics than a standard drum.

of friction as temperature rises is acceptable, but a rise of coefficient with a rise of temperature should be avoided. A rise will cause the brakes to "grab" and operate erratically. Too, if the shoes and lining are positioned to allow for a large increase of coefficient when the brake is hot, then good performance at normal temperatures is sacrificed.

Girling has found that short arcs of brake lining between 90 and 100 deg long, with coefficient of friction between 0.35 and 0.38, will avoid the tendency to "grab."

Since they use brakes with a low self-energizing factor a vacuum booster has been adopted to help increase pedal pressure.

Girling's two-trailing-shoe brake (Fig. 6) consists of two shoes, each operated by a hydraulic cylinder. The shoes are made conformable by reducing the web depths to a certain pattern. The brake is self-adjusting. As the lining wears, the hydraulic pistons follow out the shoes. Hydraulic fluid from the reservoir makes up the volume. Frictional anti-shake-back devices are used on each shoe to restrain them from vibrating away from the drum.

There is a tendency in Europe to use larger brake areas per unit vehicle weight than in the United States. For front brakes, the horsepower absorption per square inch of drum area is lower on British cars. On fast and heavy British cars two trailing shoes are used and the horsepower absorption is higher because short lining arcs are used.

American cars tend to use smaller rear than front brakes in proportion to the weight and braking

Fig. 5—Budd Disc brake has a single disc with two faces. A short caliper-type lining segment bears against these faces. Vanes between the disc surfaces force cooling air through the brake thereby aiding heat dissipation.

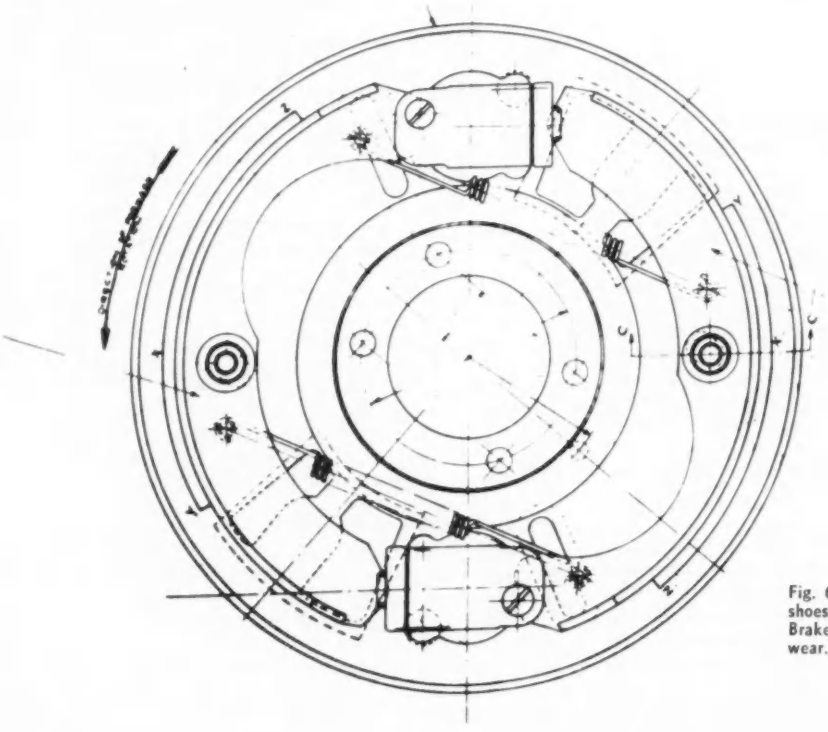


Fig. 6—Two-trailing-shoe brake consists of two shoes, each operated by a hydraulic cylinder. Brake is self-adjusting to compensate for lining wear.

distribution. The horsepower absorption per square inch of swept drum area on rear brakes is approximately 50% greater on American vehicles.

Girling has found that with the quality of linings which are available today that if a brake is designed with a limit of 2.5 hp absorption per sq in. of lining, fade will usually not be a problem. If, however, fade occurs with two-leading-shoe brakes then two-trailing-shoe brakes are used. They normally use 110 deg lining arc, but recent work on high speed cars has shown that an 85 deg lining arc improves fade resistance. Although the horsepower absorption per square inch of lining has increased in the ratio to the decrease in lining arc, stability has been improved.

By making the shoe web conformable in a pre-determined pattern the work is spread equally over the whole lining area and vibration is reduced. Also since a larger arc of the drum is left uncovered with a shorter lining, heat dissipates quicker. Girling has also found that this decrease in lining arc, and therefore volume, has not materially reduced the lining life under these conditions. Girling has a disc brake (Fig. 7) that has been used successfully in racing cars and on a large passenger bus. It uses an hydraulic cylinder to apply a pad to each side of the disc. The brake factor is equivalent to the coefficient of friction. Heat dissipation is better on the disc brake than on the two-trailing-shoe brake. The disc brake performs smoother because the disc shape does not change, whereas the brake drum shape distorts due to shoe pressures at high temperatures. Too, the disc brake does not expand away from the linings; on the contrary, it expands towards the linings.

Theoretically the brake factor of the disc brake is lower than the two-trailing-shoe brake, but this is compensated for by using a hydraulic system with a high overall ratio in the disc brake.

The disc brake has a segmental lining with 6.5 to 7.5 hp absorption per sq in. of lining. Horsepower dissipation for the disc is 0.65 to 0.75 per sq in. Thus while the lining load is approximately three times that of the drum brake, the dissipation rate per square inch of swept area is almost half that of the drum brake.

Although the lining area of the disc brake is about three times less, the total volume of lining available for wear on the disc is 10 to 15% more than a comparable drum brake. This is due to the fact that all of the lining volume can be worn away on the disc, while on the drum the middle portion of the lining arc wears away quicker than the ends.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

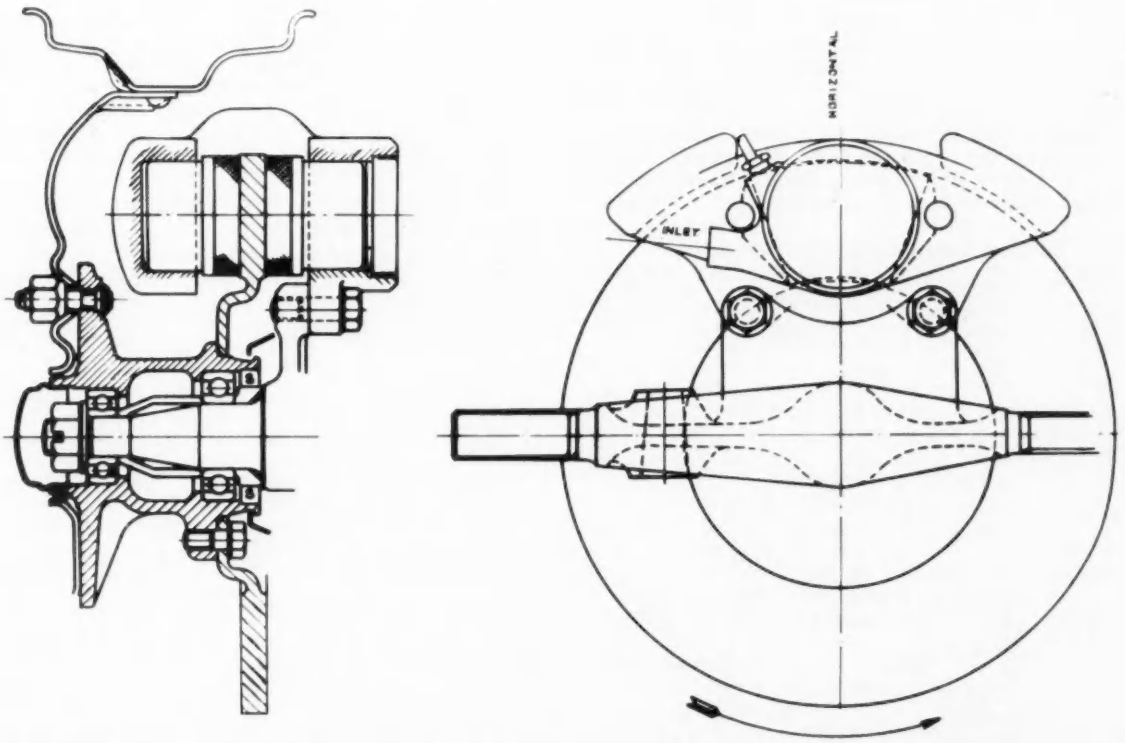


Fig. 7—Girling disc brake has no servo factor. It uses a hydraulic cylinder to apply a friction pad to each side of the disc.

Before accepting it as a new tool for evaluating lube oils, laboratories are taking a good look at . . .

The CLR Oil Test

W. G. Ainsley, Sinclair Research Laboratories
A. E. Cleveland, Ford Motor Co.

Based on paper "CLR Oil Test Engine" presented at the SAE Golden Anniversary Fuels and Lubricants Meeting, Philadelphia, Nov. 9, 1955.

THE COORDINATING Lubricant Research Oil Test Engine has been developed to replace the L-4 eventually as a laboratory tool for evaluating lubricating oils. It is now undergoing evaluation in petroleum and automotive laboratories throughout the country. Although too soon for definite conclusions, preliminary reports indicate that the CLR engine will be able to reproduce results in the same relations as previous tests with the L-4. Also it will probably have a longer life, greater flexibility, and greater ease of test servicing than the L-4.

Similar to Production Engines

The single-cylinder CLR engine is designed to perform similarly to multi-cylinder commercial engines and have the same critical operating characteristics. Fig. 1 shows the characteristics of the engine. Friction horsepower is somewhat higher and bmep is consequently lower than some commerical engines. This was done intentionally to increase the heat transfer to the oil by way of the bearings. The bore, stroke, connecting rod length, and type of combustion chamber design are similar to existing commercial engines. However, many of these items can be easily varied to study specific wear and deposit problems.

The engine's components can be lifted easily by one reasonably strong man. The largest mass is concentrated in the base casting which usually remains fixed to the laboratory bed plate. The crankcase assembly, including crankshaft, camshaft, timing gears, mainbearing, etc., can be further disas-

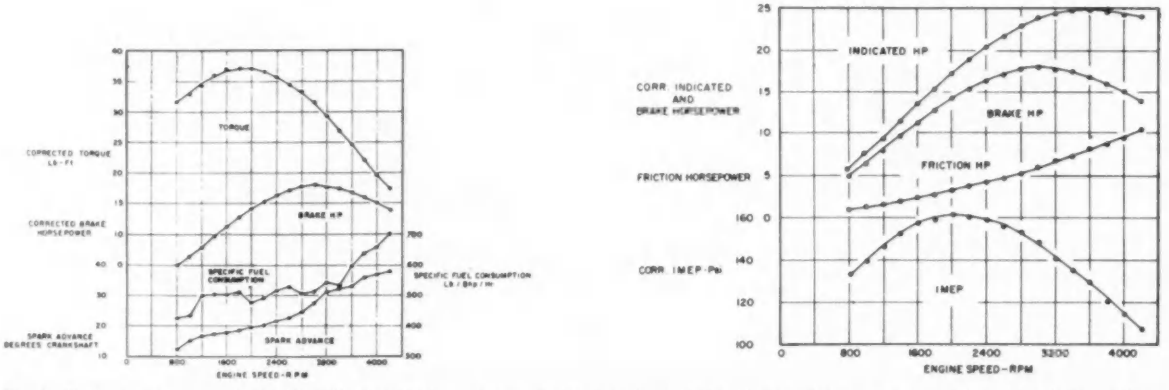
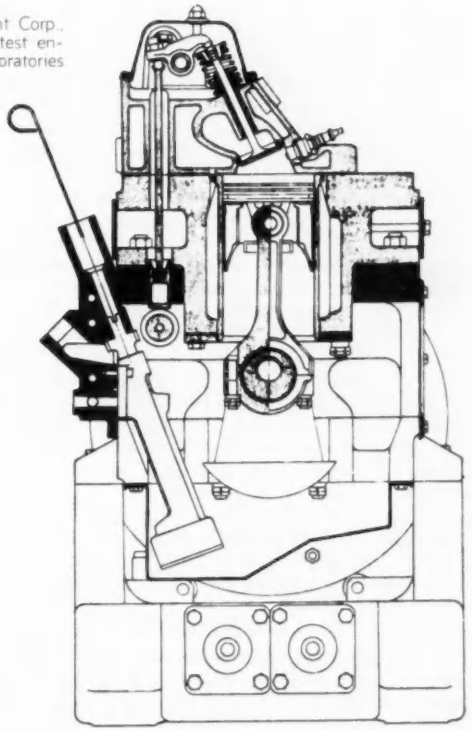


Fig. 1—Performance curves of the CLR Oil Test Engine. It was designed to have similar characteristics to commercial multi-cylinder engines. Friction horsepower is somewhat higher and bmep somewhat lower. This was done to increase the heat transfer to the oil by way of the bearings.

CLR OIL TEST ENGINE was built by the Laboratory Equipment Corp., of Mooresville, Indiana. Twenty-five of these single-cylinder test engines are now being evaluated by automotive and petroleum laboratories throughout the country.



Engine

sembled for man handling. Below is a list of the components and their weights:

Cylinder block	70.5 lb
Head	38.5
Crankcase assembly	281.0
Base	587.5
	979.5 lb

These parts were designed stronger than in commercial engines to eliminate structural failures. Excessive strength was not desirable in the lubricated wear parts, however, since one of the primary functions of this test engine is to test the lubricant at these critical wear areas.

A spiral bevel oil pump and distributor drive gear is provided on the camshaft and the connecting rod bearings are designed to correspond to critical commercial practice. The main bearings are designed somewhat larger than would be expected in a commercial engine of this size, in the hope of decreasing pound-out types of failures and to provide more frictional heat to the oil for higher internally generated oil temperatures.

The camshaft and cam follower are similar to commercial engines so that the lubrication problems of this part of the engine could be reproduced. Piston and rings were designed to reproduce commercial conditions as much as possible, considering the essential differences between a wet sleeve and cast cylinder bores. Timing gear lubrication is conventional but can be isolated from the rest of the engine if desired. A separate lubrication system is provided for the accessory drive case and the systems are divorced so that there can be no leakage from one to the other.

The oil pan is completely encased for either live steam heating or gas or water cooling so that the oil can be heated or cooled on a large surface area with a smaller heat gradient.

Total oil capacity is 1 qt so that small samples of oil can be tested.

The crankcase has machined surfaces inside—instead of rough cast surfaces—so that the engine can be cleaned conveniently and oil can drain down better.

All of the machined oil passages and oil take-offs are placed in one side cover plate to facilitate cleaning. This side plate is designed for either full-flow, or partial-flow filters and various by-pass pressure valves. For convenience the side plate also carries the oil dip-stick and distributor mounting. The variety of oil passages in the machined side plate and an external oil passage to a fogging nozzle in the cylinder housing permit a choice of oil feed systems with or without spray oxidation.

The crankcase is cast so that two camshafts can be used, permitting maximum flexibility in tests with different types of drive mechanisms. This also permits a variety of valve locations and combustion chamber designs.

The cylinder head is designed to permit a variety of combustion chamber shapes to be fitted to the cylinder without concern for external hold-down nuts, bolts, or stud location. The head is held in place internally by a unique four-stud bolt, flange, and hold-down nut assembly. Provision is made for

an optional eight-stud hold-down assembly for a future diesel design cylinder head. Another hole can be easily drilled into the head so that studies can be made with engine indicators, sampling valves, and an additional spark plug. Provisions are made for either carburetion or manifold injection of fuel. The additional hole can also be used for fuel injection into the combustion chamber.

The barrel design allows sufficient clearance for a 4-in. bore. (The present bore is 3.8 in.) Also, by substituting another cylinder housing casting, smaller bores (to 2 in.) and larger bores (to 5 in.) can be used.

The accessory drive case provides for six power take-offs. Two of these are at camshaft speed (located in rear), and four are at crankshaft speed (two located in front and rear). This is in addition to the drive for the front of the camshaft and crankshaft, and the power drive for the dynamometer on the rear of the accessory case. This results in a total of three camshaft and six crankshaft speed drives.

So, it can be seen, that a variety of test set-ups are possible. It is hoped that most of the changing test conditions dictated by reciprocating engines of the future will be within the scope of this oil test engine.

The Results So Far

One CLR oil test engine at Ford Motor Co. engineering laboratories completed an endurance test of 500 hr. (100 hr at 4200 rpm.) Critical wear compared favorably with comparable wear areas in commercial engines. Parts designed for test fixture life showed no measurable wear at this time. There was no indication of valve tossing and the engine was remarkably free from vibration.

There was some oil leakage and better control of crankcase ventilation is required. This was obtained by installing a spring loaded flutter valve in the ventilator tube. However, some further study of the sealing problem is needed.

R. K. Smith, The Lubrizol Corp., reports that they have found the durability of this engine excellent. There are two engines in the Lubrizol Corp. laboratory, one of which has operated for 1000 hr, the other for 750 hr. Total parts replacements for both of the engines include one rocker shaft, one set of lifters, two rocker arms, one set of camshaft bearings, seven sleeves, and one sprocket for the accessory drive. From Lubrizol's experience it seems very likely that, in spite of the high initial cost of the engine, the cost of running a test in this engine will compare favorably with the cost of present tests.

The engine is easy to service and the use of additional power sections will make possible "round the clock" testing with a minimum of shutdown. Lubrizol believes the CLR engine will be able to reproduce both the deposit formations and the bearing corrosion attained in the L-4 tests.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

The Philosophy of Reliability . . .

. . . emphasizes environmental tests. Results are conveniently measurable and produce facts helpful in redesign of a component.

Based on paper by **Charles T. Morrow,** The Ramo-Wooldridge Corp.

THE approach to reliability of weapon systems can be made more quantitative by stating numerical reliability objectives in terms of the ratio of successful to total missions. This is done easily at the system level and the success of the system in attaining the prescribed reliability, if it does, is at least marginally verifiable.

Reliability objectives are still useful at component and subassembly levels, but they encounter some practical difficulties. If we assume failures to be completely independent, we find the reliability of the system to be equal to the product of the reliabilities of its components—and likewise for further subdivisions. Using this formula and some simple arbitrary rule for apportionment of reliability among components, among subassemblies, and so on, we can prescribe reliability objectives at any level. But not many subdivisions take place before the objectives become phenomenally close to unity, or in other words to perfection, and if achieved are not verifiable directly in a program of permissible size. The numbers certainly make the magnitude of the reliability problem vivid and explain clearly why we have not had more spectacular success with it.

When failures are not entirely independent, the requirements are less severe, but it is unsafe to assume that many of the failures are not independent.

Thus, as reliability objectives are prescribed at lower and lower levels of subdivision, we have a small doubt as to the realism of the prescriptions and we encounter difficulty in verifying that the objectives have been met. Furthermore, although the objectives are useful as an aid to design choices in special cases, this type of application is limited. We find it necessary, therefore, to prescribe supplementary measures such as environmental tests which correlate only partially with the reliability goals, but can be used as requirements and do lead more frequently to information useful in design or design changes. The statement of the test serves indirectly as a definition of the service environmental conditions, but it is basically a feasible test rather than a detailed description. (Paper "How Environmental Test Conditions and Their Combinations Influence the Reliability of a Product" was presented at SAE Aircraft Research Seminar, University of California, Los Angeles, Dec. 6, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Fatigue Failures . . .

. . . appear to be related to "mistakes" in the crystal structure of a ductile metal.

Charles M. Schwartz, Battelle Memorial Institute

Based on talk given to Division IV, Residual Stresses of the SAE Iron and Steel Technical Committee, Detroit, Jan. 11, 1956.

JUST what the relationship is between fatigue failures and imperfections in the crystal might be deduced from correlation of (1) x-ray measurements of atoms dislocated by microstresses from their ideal position in the crystal lattice with (2) fatigue data.

It may be that stresses created in the metal as it cools from the molten state induce dislocations in the crystal structure which, under cyclic stressing, move along the crystal until they pile up at impurities or at the surface of the crystal. And it may be that cyclic stressing itself creates dislocations (in addition to those induced by residual stresses) that accumulate until an actual discontinuity—or fatigue crack—exists.

The idea that there are such weakening dislocations of atoms in the crystal lattice has taken form over the last 25 years as investigators have tried to explain the weakness of actual crystals. (The observed yield strength of a well annealed crystal of a typical metal is only 0.01% of the computed force it would take to slide one layer of atoms over the adjacent parallel plane in a perfect crystal of the metal.)

The dislocations are now known to exist. In a well annealed metal crystal, there are something like 100,000,000 dislocations per sq cm. In a cold-worked specimen the dislocation density is increased ten-thousandfold.

Dislocations move readily through the crystal under small applied stresses. But irregularities due, for example, to impurities in the metal impede the motion. The result is increased energy in the crystal associated with distortion of the crystal in the region of each dislocation.

It's easy to imagine that repeated stressing might add dislocation to dislocation say, against a hard inclusion or along a sub-boundary wall. If the accumulated dislocation occurred along a wall perpendicular to an operative slip plane, the associated high stress might start a crack along the slip plane.

Observers have reported that fatigue cracks usually do start in an operative slip plane rather than along the plane of a crystal's least resistance to brittle fracture. This is true even of steel, which has cleavage planes within its crystals upon which fracture occurs readily under tension, at low temperature (−100 C). However, at room temperature, fatigue cracks form readily in steel along slip planes which do not coincide with the cleavage plane.

One way to find out if, when dislocations pile up, they do lead to fatigue cracking is this: Measure the number and distribution of dislocations in the crystal lattice of specimens, subject the specimens to repeated stressing, and measure number and distribution of the dislocations again. Then check correlation of dislocation buildup with fatigue failures.

An advance in the technique of measuring displacements in crystal lattices by the x-ray method may make it possible to do this.

The principle of the basic x-ray line-shift method used to measure directional stress is this: A perfect unstrained crystal lattice reflects x-rays in a series of sharp lines. A force applied to the crystal changes the spacing of the atomic planes and results in a corresponding shift in each x-ray line.

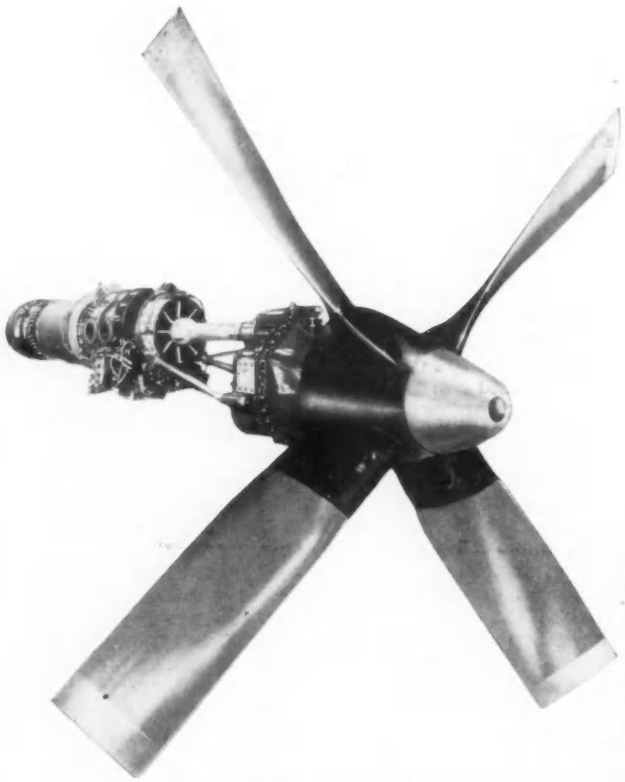
In the actual, imperfect, unevenly stressed crystal the local variations in spacing of its planes convert each x-ray reflection line into a band. The broadening of the line into a band by the stresses due to the martensite transformation has long been treated as a necessary evil, simply reducing the sensitivity for measuring directional stress.

Experimental Check Now Possible

But recent work by B. E. Warren and B. L. Averbach of the Massachusetts Institute of Technology makes it possible to study the "shading" of the band. The shading can be used as a measure of the variation of atomic dislocations within the crystal. This new technique will be explored further at Battelle Memorial Institute.

If application of this technique revealed that a specimen which initially showed the usual scattered distribution of dislocations developed a pile-up of dislocation regions after repeated stressing, and if the change in distribution of the dislocations correlated with occurrence of fatigue cracking, there would be strong evidence for the dislocation theory of failure in ductile metals. Too, if the total amount of dislocation increased during cyclic stressing, there would be indication that the stressing introduces dislocations in addition to those due to residual stresses.

Allison Power Package for the



The Allison Model 501-D13 turboprop powerplant is the commercial version of the military T56-A-1 engine, which was described in

SAE Journal, February 1956, pages 23-26: "Allison T56 Turboprop Features Flexibility"—J. B. Wheatley, D. G. Zimmerman, and R. W. Hicks

The Lockheed Electra transport, which will be powered by the Allison turboprop, was described in

SAE Journal, January 1956, pages 56-60: "ELECTRA: Turboprop Transport for 1958 Delivery"—Hall L. Hibbard

THE Allison power package for the Lockheed Electra initially consists of the Model 501-D13 turboprop engine and the Model A6441FN-606 turbopropeller.

After approximately two years of D13 production, the engine will be changed to a higher rated model, the 501-D15. Both the Electra aircraft, including nacelles, and the 606 propeller were designed from the start for the -D15 engine ratings. In addition, the separate reduction gear and torquemeter assemblies and struts of the -D15 model engine are being supplied initially on the -D13 engine, so that only the gas turbine power section is involved in the rating change.

Since the power section represents only 40% by weight of the complete power package, and many of its components and assemblies are interchangeable between -D13 and -D15, the advantages are obvious. Allison can supply fixed-cost kits for converting the -D13 to the -D15 power section at overhaul when the -D15 reaches production.

The 501-D13 turboprop engine is the commercial version of the military T56-A-1 engine. The -D13 is characterized by the offset-down propeller shaft as compared to the offset-up propeller shaft of the -1. The -1 has been in production since January 1955 and will have had a rising production history of two and one-half years before any appreciable number of Electra engines is required. It is expected that some 400,000 engine hours will have accumulated on a cargo-transport type airplane before the Electra starts carrying passengers.

The sea level performance of the -D13 engine is essentially the same as the T56-A-1. The -D13 engine incorporates certain additional or changed features desired by the airlines or airplane manufac-

R. M. Hazen, Dimitrius Gerdan, and
R. R. LaMotte

Allison Division, GMC

Based on paper "The Allison Power Package for the Lockheed Electra" presented at the SAE National Aeronautic Meeting, New York, April 10, 1956.

Lockheed Electra Transport

. . . provides for a higher-rated power section, the Model 501-D15, due after two years of -D13 production. Other features are protection against overspeed and negative thrust—and a quiet "low taxi" rpm range.

turer or proposed by Allison for increased interchangeability with the -D15 higher rated model. Among the changes are provisions for use of kerosene, use of an extreme-pressure lubricant, and a low-rpm taxiing regime.

Fuel—The airlines specified kerosene as the primary fuel with JP4 as an alternate, whereas the T56 uses JP4 or gasoline. Kerosene has a 0.5% lower normal heating value than JP4 and increases specific fuel consumption by this amount. Kerosene is considerably less volatile than the other fuels and appreciably affects cold and altitude starts. The energy of the ignition system was doubled to take care of this factor. Fortunately only minor modifications in the fuel and combustion systems were required for this fuel change.

Oil—Based on comparative tests for maximum overhaul time and minimum overhaul costs Allison recommended the use of an extreme pressure additive turboprop oil rather than the turbojet oil specified by the military for logistic reasons. This was adopted. The additive oil is specified on all T38, T40, and YT56 engines in use.

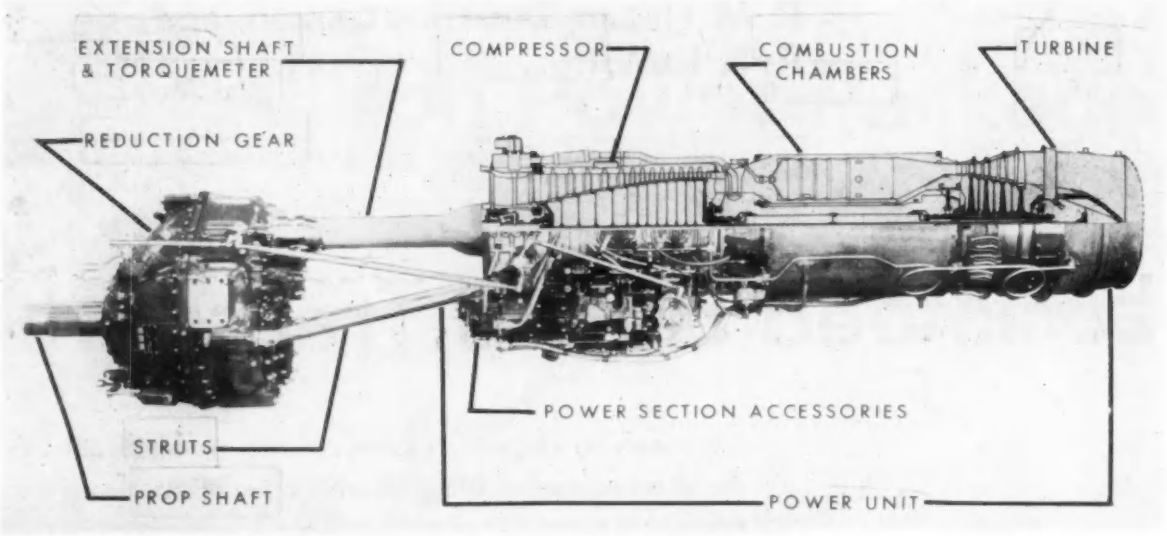
Reduction Gear and Torquemeter Assembly—The complete separate reduction gear assembly, the torquemeter assembly with its torque tube housing, the two interconnecting struts, and the control linkages to the propeller and power section are interchangeable from engine to engine. They can be boxed, shipped, and overhauled separately from the power section.

The separated gearbox permits a demonstrated highly efficient ram recovery in the duct which is equivalent in the airplane to supplying more power and better fuel consumption at altitude than can be obtained with an integral gearbox. There is also greater flexibility in inlet duct location which can be used to minimize foreign object, hail, and rain ingestion by the engine.

The separate gearbox also allows space for and has provisions for driving all of the aircraft-required accessories on the back face of the gearbox. This minimizes frontal area for low drag and is convenient for access and service. The reduction gear assembly retains all of the features of the T56-A-1, namely, the mechanically actuated negative torque signal, the propeller brake, the decoupler, the offset spur gear driving a planetary gear assembly, and accessory drive provisions for the starter, alternator, generator, hydraulic pump, and two tachometers.

Design provision has been made for the heavier propeller required for commercial use based on the higher -D15 ratings. All gearbox parts developed for the higher rated second military model have been included. The timing of first production Electra engine deliveries permits this.

Low Taxi RPM—The military were satisfied with a ground idle and taxi regime of 1080 propeller shaft rpm. The commercial engine with gear reduction of 13.54:1 gave a value of 970 rpm, which was lower—but still not as quiet as desired. Noise tests indicated the 970 rpm value was undesirable around the passenger loading ramp and when taxiing about the airport. A "low taxi" rpm provision was, therefore, added for a propeller rpm of 737 which can supply adequate power for all normal taxi operation. This reduces noise in the loading area to a level comparable to present commercial levels. "Low taxi" is obtained by cockpit switch selection



THE MODEL 501-D13 TURBOPROP engine has an offset-down propeller shaft. It is the commercial version of the military T56-A-1.

which operates a solenoid to bias the engine governor from the high taxi to the low in the beta or scheduled control portion of the coordinating control, which is used only on the ground. Since some air bleeds are open during the "low taxi" operation, overboard ducts have been provided for the air discharge.

Ice Ingestion Tests

Allison has completed an interesting series of tests on ice ingestion on the 501 engine in which artificial hailstones were made in ½ to 3 in. ball sizes, "heat treated" to maximum toughness, and fired into the airplane duct on an engine running at full speed, at velocities of 200, 300, and 425 mph. No damage was done to the engine even when 1½ and 2 lb charges were muzzle loaded onto a 3 in. ball and fired in one shot, although the duct had some sizeable dents. Tests were repeated directly on the engine, again without incurring serious damage.

Safety Features

The functions of control on a turboprop engine are so intimately related between engine and propeller that they can be considered only as a power package. The engine-propeller combination functions normally with electrical power cut off, electrical power being used only for trimming and checkout procedures. All of the following features are subject to daily or preflight checks.

Speed Control—Powerplant rpm control under all normal flight conditions is the propeller responsibility. The speed-sensitive governor controls hydraulic flow and thus blade angle to maintain a constant rpm. It is a most reliable system of basic control. In case of malfunction tending to cause overspeed a mechanical pitch lock, an overspeed governor, and propeller feathering are provided.

The first protective device on overspeed is the mechanical pitch lock in the propeller. It is normally held out of engagement by low hydraulic pressure against the spring-loaded lock. The pitch lock mechanically prevents decrease pitch when triggered by a speed-sensitive valve functioning independently of the governor which dumps hydraulic pressure at about 2% overspeed.

The second protective device on overspeed is the overspeed governor of the turbine fuel control which is set at about 4% overspeed. The fuel control governor is of the identical type used to control turbine rpm of all turbojet engines and has the same reliability. It should also be noted that the so-called "4% overspeed" of this engine is the same as rated speed of all T38 and T40 turboprop engines and therefore is in effect no overspeed at all. This engine protection means that the propeller could go to flat pitch or the driveshaft to the gearbox or propeller could fail without destructive overspeed of the power section.

If a combination of conditions should arise in which none of the above automatic overspeed pro-

Table 1—Allison 501-D13 Guaranteed Ratings at Standard Sea Level Static Conditions

Ratings	RPM	Turbine Inlet Temperature, F.	Equivalent Shaft Hp	Fuel Consumption Lb/Hr-ESHP
Take-Off	13,820	1780	3750	0.540
Maximum Continuous	13,820	1780	3375	0.552
Climb 92%	13,820	1645	3105	0.566
Cruise 80%	13,820	1557	2700	0.589
High Taxi	13,370		535	1.46
Low Taxi	10,000	1015	88	6.25

visions are effective, there are still two means of stopping the powerplant by feathering the propeller which are available to the pilot:

One is a "manual feather" button which electrically calls for feathering through the electric feather motor which has an adequate oil supply for full feather operation independent of the regulator oil supply. The power unit can be cut off by moving the power control to cut-off.

A second and faster way is to push the "emergency lever" in the cockpit which mechanically actuates an autofeather valve in the propeller hydraulic system and cuts the fuel to the nacelle.

In any turboprop engine it is essential to operate fairly close to a constant speed regime during flight for maximum efficiency, since the compression ratio and therefore efficiency is a function of engine speed. This gives very fast power or thrust control to the throttle since the propeller and engine inertias are not an important factor in power changes. This fast response of a turboprop engine is a very desirable feature in a normally operating engine. However, it does introduce certain problems in the negative thrust area which require recognition and necessary protective provisions against the high power absorption characteristics of a windmilling compressor and propeller when power is lost at the higher speeds of a turboprop powered aircraft.

The basic safety provisions of the Allison power package are based on the following principles: The primary protective features must be hydraulic or mechanical throughout (not dependent on electrical power). They must be fast acting and automatic. Secondary protective features will provide alternate hydraulic or mechanical systems insofar as possible with minimum dependence on electrical systems. Finally, electrical operation can provide additional protection as desired.

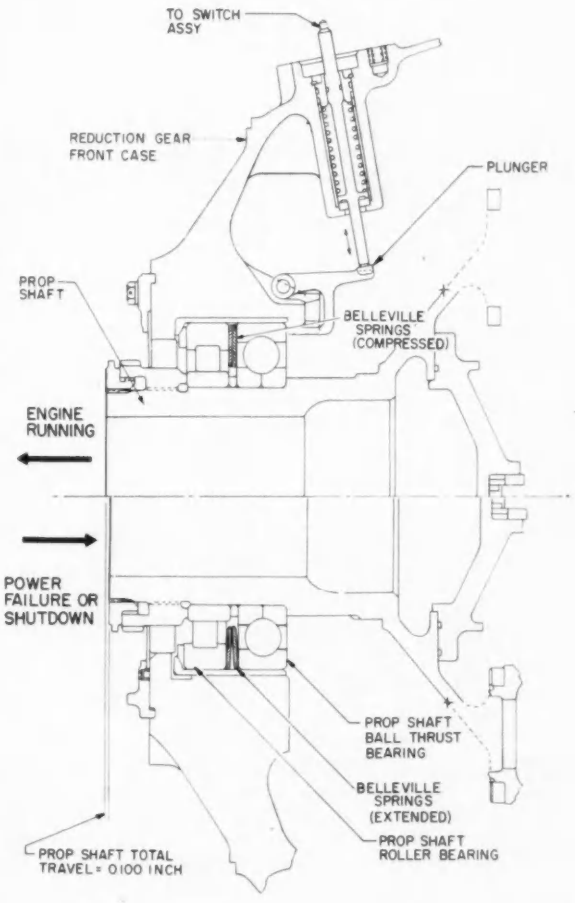
All of these devices with one exception involve initiating or completing feather of the propeller, which may be accomplished by two means hydromechanically and one separate means electrically. The one exception is the decoupler which only functions in case the propeller alternates fail to operate.

Negative Torque Signal

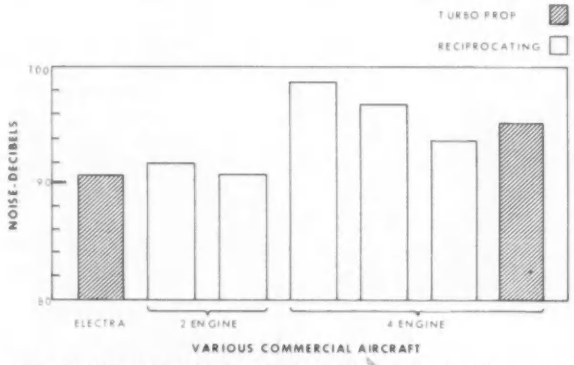
The basic protective system against inadvertent negative thrust is the negative torque signal (NTS) operation. A mechanical negative-torque-sensing device in the engine gearbox operates on a pin to a gearbox-mounted linkage connected to the propeller NTS control lever which mechanically actuates the NTS hydraulic valve. The valve ports oil directly to the increase pitch side of the blade torque units, causing an immediate blade angle increase, and prevents high drag conditions. The system is of the "non-committal" type; that is, if the condition is only momentary, the NTS control is returned to normal position and the governor resumes normal governing operation. If the condition persists, feathering is continued to hold a low fixed power absorption.

Take-Off Autofeather

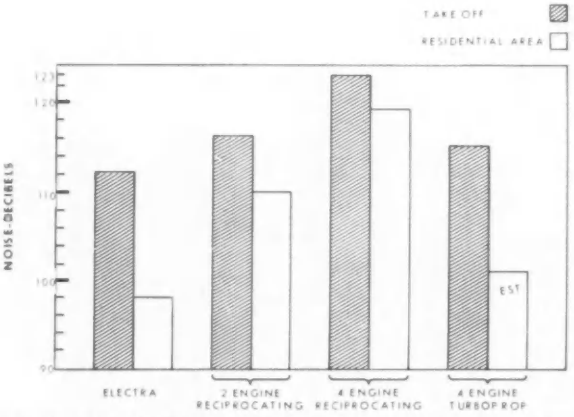
During the take-off period when the pilot is busy and to avoid any possibility of shutting down a functioning rather than a malfunctioning powerplant during this critical period, it was decided to include an autofeather system for take-off which would be of the "committed" type. The thrust-sensitive device in the gearbox operates a switch energizing a solenoid on the gearbox. The solenoid actuates the autofeather lever and its valve to feather the propeller completely. The same electrical signal also shut off the necessary system to stop the engine and energizes the feather motor to complete the feather



THRUST-SENSITIVE SIGNAL for autofeather provides a separate means of autofeathering during take-off if desired by the pilot. The thrust bearing is mounted against belville washers set to flatten at a few hundred pounds of positive thrust. If for any reason power is lost on one engine during take-off the belville washers force the bearing aft. This operates the linkage to the outside of the gearbox. The signal not only actuates the autofeather lever to feather the propeller completely, but also shuts off the necessary systems to stop the engine. The system is armed for take-off only and is automatically disarmed when throttle is moved to "maximum continuous" power or less. The other three engines are automatically disarmed in case one engine autofeathers.



AT LOADING RAMP AND TAXI OUT with the "low taxi" rpm provisions the Electra's noise levels will about equal those of two-engine commercial aircraft and be generally better than other four-engine aircraft. There will be slightly higher levels of noise directly forward of the aircraft due to compressor noise, about the same at the side in the plane of the propeller, and less at the rear than conventional airliners produce.



AT START OF TAKE-OFF ROLL the Electra is expected to have 3 to 10 db lower levels than existing commercial aircraft. It will quiet down noticeably after a relatively short roll. Noise level in nearby residential areas will be at least 10 to 20 db less than with reciprocating powered aircraft. This is due to low tip speed, low exhaust noise, and the low power loading of the Electra.

cycle. This system is armed only for take-off and is automatically disarmed when throttle is moved to "maximum continuous" power or less. The other three engines are also automatically disarmed in case of one engine autofeathering.

Emergency Feathering

In case of a nacelle fire or other reason for complete shut off of any one powerplant at the pilot's will, an emergency feather device is provided. A positive mechanical linkage from the cockpit emergency control is connected to the engine coordinating control directly to the condition lever on the propeller. The "Emergency" position overrides the interconnected power lever control linkage which mechanically shifts both the governor piston and the autofeather valve into the increase pitch position. At the same time the electrical feathering pump motor is energized so that, with its own reserve oil supply, feathering is accomplished even if no oil is left in the main regulator or the main system pumps are inoperative.

Manual feathering may be accomplished at any time from a feather button in the cockpit through the electric feather motor. This can be done without the engine running, as well as operating, for checkout purposes.

Prevention of In-Flight Reversal

A rugged mechanical low-pitch stop operating directly on the blade angle master gear provides positive protection against inadvertent propeller reversal in flight. It is strongly spring loaded to lock the blades against the hub in the decrease-pitch direction. It can be disengaged only when the pilot shifts through the flight idle quadrant stop into ground operation and reverse pitch selection when a rotary selector valve is mechanically actuated to provide low pressure oil to overcome the pitch lock spring pressure. This then permits reverse pitch to decrease ground roll.

Decoupler

With the above safety features there would appear to be no need for automatic decoupler between the power section and gearbox. There has been no demonstrated need for this unit in thousands of hours of flight since the NTS system was provided. On the other hand the decoupler is well developed and had worked every time it was needed prior to NTS availability, which was a very small number of times. It was decided to retain this unit set at a considerably higher torque setting as a backup or insurance safety device against double or triple simultaneous other failures until service use demonstrated there was no requirement for it. No daily check is provided.

The above safety features sound somewhat complex when listed by themselves. However, it should be remembered that the majority of them are already provided on present propeller-driven commercial aircraft or are incorporated now due to experience of the airlines with previous serious malfunctions or simultaneous multiple failures on existing types. The high drag characteristic of power turbines under certain failure conditions does require protective devices. This is true whether they are of the single-spool, two-spool, or gas-coupled types because of the possibility of lockup of concentric shafting. Protective devices required are a rather small penalty for the many advantages obtained with turboprop power.

Paper on which this abridgment is based contains a description of the Aeroproducts 606 propeller, which is part of the power package for the Electra, as well as additional details on the 501-D13 engine. For complete paper, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

FUELS

For Turbine Transports

Hugh Harvey, Shell Oil Co.

Symposium secretary's report of session on Fuels and Fuel Systems for Turbine Transports held as part of the SAE National Aeronautic Meeting, New York, April 12, 1956.

THE turbine engine is noted for the wide range of fuels on which it can operate, but in an aircraft this versatility is somewhat limited.

These limits are imposed by the environment in which it must operate, like varying altitude and extremes of heat and cold, the restricted quantity of fuel the aircraft can carry, the relative hazards of available fuels, and, last but not least, the necessity for maximum utilization of available energy. Considerable thought has been given to the possibility of using heavy distillates, for example, but at the present state of the art, the weight and cost of providing heat to keep them warm enough to flow would be prohibitive.

Fortunately, the engine manufacturers, the builders of the airframes, the fuel suppliers, and the operators are cooperating and pooling their resources so that there is every assurance that the transports scheduled for commercial service will benefit from coordinated consideration of their fuels and fuel systems.

Basically, the factors so far as the operators are concerned are the economics and—as always—safety. Because the fuel consumption of the turbine engine is greater than that of the reciprocating engine, fuel costs will represent a much larger proportion of direct costs than heretofore. A jet transport will fly only 15–16 passenger miles per gal, or about one half the 28 passenger miles per gal a DC-6B would fly, assuming a 65% load factor in each case. Estimates of fuel costs as a percentage of direct operating costs range from 25 to 40%.

World-wide consumption of commercial turbine fuels by 1963 is estimated at 60,000,000 barrels per year. Hence, availability will also enter into all

Information in the accompanying article is from a symposium on Fuels and Fuel Systems for Turbine Transports held as part of the SAE National Aeronautic Meeting, New York, April 12, 1956. Serving on the symposium panel were:

H. A. Murray, co-chairman
California Texas Oil Co., Ltd.

J. S. Harris, co-chairman
Shell Oil Co.

Hugh Harvey, secretary
Shell Oil Co.

F. G. Dougherty
Allison Division, GMC

D. P. Huddie
Rolls-Royce, Ltd.

L. R. Jordan
Douglas Aircraft Co., Inc.

J. H. MacMillan
Boeing Airplane Co.

E. R. Schuberth
Lockheed Aircraft Corp.

J. E. Walker
de Havilland Aircraft Co., Ltd.

Table 1—Aviation Turbine Fuel Specifications

	British Ministry of Supply DERD 2482	U. S. Military MIL-F-5624C (JP-4)
Gravity, °API	(Report)	45–57
Flash Point, F		
minimum	110	—
maximum	—	—
Freezing Point, F		
(maximum)	–40	–76
Viscosity, Kinematic,		
cs at 0 F	6 max.	—
Color	Not greater than 4.0 Lovibond	—
Distillation, F		
IBP	—	(Report)
10% Evaporated	—	(Report)
20% Evaporated	392 max.[a]	290 max.
50% Evaporated	—	370 max.
90% Evaporated	—	470 max.
End Point	572 max.	(Report)
Loss, %	1.5 max.	1.5 max.
Residue, %	2.0 max.	1.5 max.
Reid Vapor Pressure		
Psi	—	2–3
Total Sulfur %	0.2 max.	0.4 max.
Mercaptan Sulfur, %	—	0.005 max.[b]
Aromatics, %	20 max.	25 max.
Olefins, %	—	5 max.
Net Heating Value,		
Btu per lb	18,300 min.	18,400 min.
Aniline-Gravity		
Constant	—	5,240 min.
I.P. Smoke Point, mm	—	(Report)
Smoke Volatility		
Index	—	54.0 min.
Corrosion (Copper		
Strip)	—	Slight discolor max.
Water Tolerance		
(Reaction), ml	2.0 max.	1.0 max.
Existent Gum,		
mg per 100 ml	6 max.	7 max.
Potential Gum		
(16 hr), mg		
per 100 ml	—	14 max.
Total Acidity, mg		
KOH per g	0.10 max.	—
Additives		
Anti-oxidant	—	Permitted[c]
Corrosion	—	Permitted[c]

[a] Recovered
[b] Not required if Doctor sweet
[c] Approved types only.

considerations to a considerable extent, though the petroleum companies give assurance that they can and will supply any physically practical fuel.

The airlines feel that any specifications that would limit availability and increase costs should be assessed in terms of increased performance, if any, that might be expected from the use of a premium fuel. Increases in the complexity and cost of aviation gasolines for piston engine transports resulted in increased payload and range, but many proposed specifications that would increase the cost of jet fuels do not promise any increase in performance.

Kerosene Versus JP-4

For airline use, the choice seems to be between a kerosene fuel and the wide-cut product known in this country as JP-4. (See Table 1.) With one exception the universal turbine fuel world-wide for all civil operation is kerosene meeting Specification DERD 2482. For example, the fuel used by Capital Airlines in their Viscounts meets this specification.

In both the United States and Great Britain, military operations for the most part employ JP-4 fuel which meets MIL-F-5624C or DERD 2486, and it is this type of fuel that is used by Trans-Canada Air Lines in their Viscounts.

Fuel selection should not be decided by an individual operator until all factors have been weighed, everyone agrees. Trans-Canada chose JP-4 on the basis of the detailed design of the aircraft and consideration of the regions in which it was to operate. These factors plus the price advantage that JP-4 happened to enjoy in the regions served by Trans-Canada made its choice obvious.

In this country, the airlines have shown a preference for a kerosene fuel. However, Allison favors the use of JP-4 fuel because this is the main fuel upon which all current American engines are developed for military applications. Allison reasons that should the airline operators select JP-4, the military and commercial experiences would complement each other for a maximum and mutual benefit.

In Rolls-Royce's service experience with the Dart turboprop in Trans-Canada's Viscounts, the only trouble reported as attributable to the fuel has been an increased rate of wear of the swash-plate slipper pads in the Lucas fuel pump. There is, it appears, some doubt as to how much of this wear is caused by foreign matter in the fuel, but there is no question, Rolls-Royce feels, that the lubricating properties of JP-4 are marginal. For this reason steps are being taken to improve the resistance of the fuel pumps to wear.

Stability

Some questions have been raised, particularly by Pratt & Whitney Aircraft, about the high temperature stability of jet fuels. This is a problem that will undoubtedly become more serious as higher Mach numbers and altitudes become more common, and as greater use is made of fuel-oil heat exchangers. In 23,500 service flying hours, Rolls-Royce has found that no fuel system deposits have yet been caused

by fuel-oil heat exchangers. Perhaps this is due to the fact that Rolls-Royce engines are designed so that, with correct operation, the maximum low-pressure fuel temperatures will not exceed 175 F and the maximum high-pressure fuel temperatures will not exceed 210 F.

Fire Hazard

Douglas Aircraft has studied the behavior of JP-4, kerosene, and Grade 115/145 aviation gasoline when exposed to conditions simulating those that could be expected to exist around an engine in an accident. In addition to these fuels, MIL-O-5606 hydraulic fluid and MIL-L-7808 synthetic turbine oil were observed under the same conditions. These materials were dropped, poured, sprayed, and squirted onto a heated metal plate that simulated the surface of an engine. In most of the tests, a shield was placed above the plate and air of known velocity was passed through the space in which ignition occurred. Generally speaking, increasing air velocity increased the minimum ignition temperature. A summary of the tests is shown in Table 2 in which the ignition temperatures are compared with the autogenous ignition temperatures as measured by ASTM method D 286—30.

Based on experience with the Comet, de Havilland has compiled information on the relation between fuel temperature in the fuel tanks during flight and the fuel ignition range. An example of the type of information collected by de Havilland is given in Fig. 1, which shows the ignition limits to be expected in the integral wing tanks of the Comet as a function of fuel temperature and flight duration. The data, according to de Havilland, show no clear-cut safety advantage for one fuel over the other during flight. However, during the takeoff and landing, kerosene is shown to have the advantage. Under these

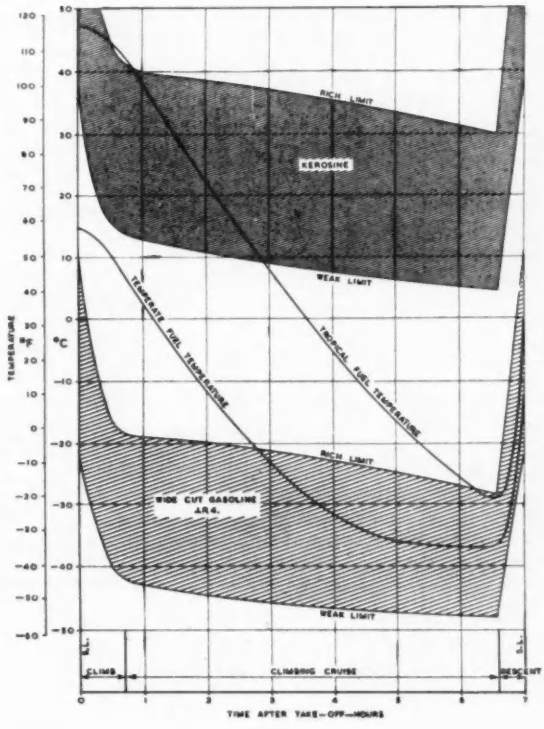


Fig. 1—Predicted temperature of fuel in Comet integral wing tanks is such that ignition could occur whether the fuel is kerosene or JP-4.

There is no clear-cut safety advantage with one fuel over the other in flight. During take-off and landing, kerosene shows to some advantage in case of mishap. Under these conditions the only safe ignition limit is the weak one. (An over-rich mixture will soon dilute to a hazardous mixture.)

Shaded areas represent ignition range of fuel-air mixture in tank.

Table 2—Summary of Results

	ASTM Method Autogenous Ignition Temperature	Model Tests			
		[a]Minimum Ignition Temperature, F (No Airflow)	Minimum Reproducible Ignition Temperature, F (No Airflow)	Ignition Temperature with 1 fps Ventilated Airflow	Ignition Temperature with No Shield
JP-4 Fuel	595	680	740	930	No Ignition Below 950 To 1000 F
MIL-O-5606 Hydraulic Fluid	495	600	630	760	
MIL-L-7808 Oil	750	750	800	950	
Kerosene	515	560	660	750	
Aviation Gasoline (Grade 115/145)	1010	—	—	—	—

[a] Lowest temperature at which ignition occurred during model test; difficult to reproduce.

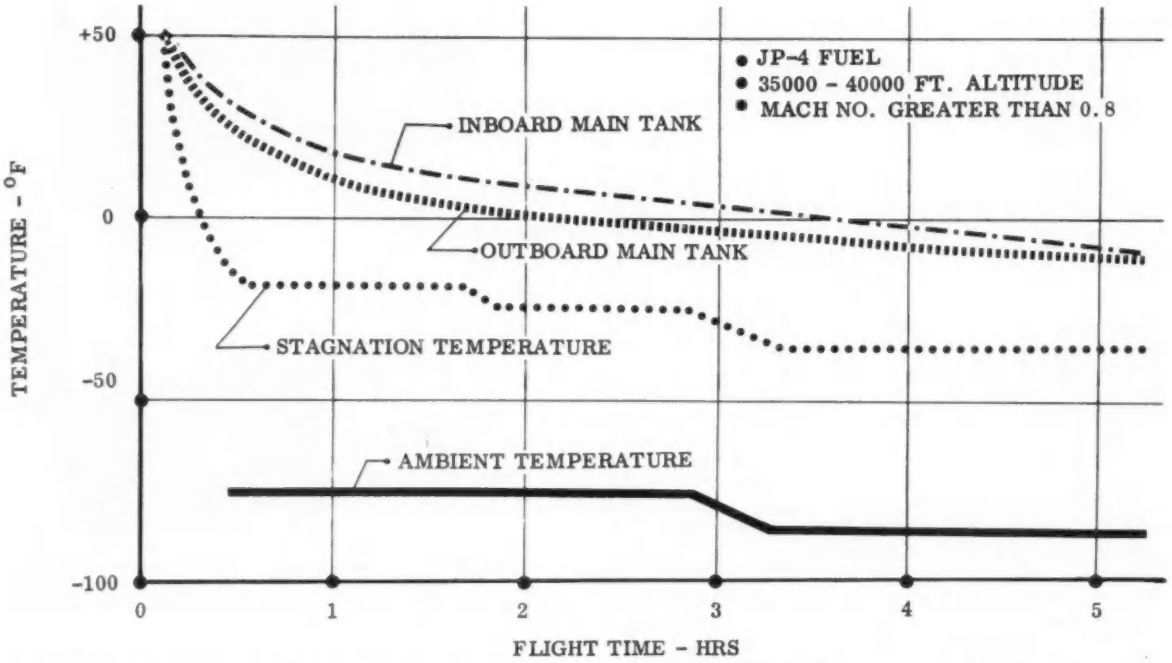


Fig. 2—Flight test of Boeing 707 prototype shows that fuel temperature tends to approach stagnation air temperature as flight continues. Following climb to 35,000 ft, a fast cruise was flown for approximately 1 hr. Then speed was dropped back to Mach 0.8 for a slow rise to 40,000 ft. With JP-4, there was no indication of a temperature gradient between the top and the bottom of the fuel tank. With kerosene on a subsequent flight, there was a temperature difference of 10 F or more. Reason was that the higher viscosity of the kerosene-type fuel eliminated the natural circulation in the tank; hence the heat was conducted to the bottom of the tank.

conditions, fuel temperature above the rich limit temperature for ignition is no guarantee of safety, since a rich vapor mixture is soon diluted. "Low volatility fuel must therefore be safer," de Havilland concludes. "As the NACA tests have shown, fuel mist projected from a tank in a crash presents a serious danger, regardless of the volatility of the fuel. This, however, is an added hazard, not an overriding one, since many crashes of mild or medium severity can happen without this mist occurring."

Fuel Temperatures

Fig. 2 shows temperatures recorded in the fuel tanks of the Boeing 707 as a function of flight time. During this flight, the tendency was noted for the fuel temperature and temperature of the wing structure to approach the stagnation air temperature (ambient temperature plus the ram temperature rise) with increasing flight time.

In-flight observations made by de Havilland with the Comet II and III indicated that the smallest temperature differential between ambient air and fuel was about 50 F. The lowest fuel temperature so far recorded in the Comet tests has been – 34 F. De Havilland has reason to believe that the lowest fuel temperature to be expected will be about – 49 F. This is 9 F below the specification freeze point of the kerosene used on the Comet. However, tests on the pumpability of this fuel show that it can be pumped from a tank without difficulty at – 49 F. De Havilland's tests, in fact, show it is pumpable down to – 58 F. Pumpability is, of course, a function of fuel characteristics, not of design of the fuel system.

On the other hand, Boeing's experience indicates that below the freeze point, kerosene tends to cause cavitation at the inlet of the boost pump with the result that flow rates fall off. In the Comet, fuel temperature indicators are provided so that undesirable low temperatures can be detected and suitable reduction in altitude be made to regions of higher ambient temperature before aircraft performance is affected.

Filter clogging is another consequence of low temperature operation. In the latest Comets, fuel line heaters which serve the dual purpose of dealing with

wax and ice have been installed. These heaters are supplied with hot air from the engine compressors and will give fuel temperature increases of the order of 99 F at 42,000 ft.

Water in the Fuel

The presence of water in the fuel and the resulting blocking of filters and screens with ice can be a serious problem. Turbine-powered aircraft are much more susceptible to water than reciprocating engine aircraft because turbine aircraft fly in the higher, colder regions and because of the filters and small orifices in their fuel systems.

It is much more difficult to remove water from turbine fuels than from aviation gasoline in storage because of its lower settling rate in heavier fuels, and the opportunities for the water to enter the system or come out of solution may be greater because of the low temperatures encountered in the operating regimes of the turbine aircraft.

However, turbine aircraft are not the only ones suffering icing in the fuel system. Incidents have been reported of serious malfunctioning of reciprocating aircraft engines because of the icing of filters. Lockheed has made an intensive study of the factors influencing ice formation and these are listed in Table 3. Lockheed has also investigated possible methods for overcoming icing and has had encouraging preliminary results with a fuel additive.

During the winter of 1952 several cases of filter icing occurred when the Comet was operating in Europe. The theory was advanced that the icing was due to landing with reserve fuel in certain of the tanks, the temperature of which was of the order of – 4 F. These tanks were then filled with fuel at a temperature of 40 to 50 F with the result that the final mix of fuel in the tanks was below the freezing point of water. Any water introduced into the tank with the fuel would then immediately be frozen out and remain frozen so that it could not readily be given up to the atmosphere. To assist in proving this point, a Comet was sent to Rome during the winter where a rapid turn around was made to simulate the conditions expected. These were confirmed, for filter icing was experienced on the return flight.

This brought de Havilland to the conclusion that the possibility of filter icing must be accepted and provision made to overcome it, so the Comet II and later versions were fitted with fuel line heaters.

Dissolved water is not, of course, the only problem. Water can also be pumped in with the fuel or carried along in suspension with dirt in the fuel. But special techniques developed for handling the turbine fuel used by Capital give assurances that this free water can successfully be excluded up to the time the fuel enters the aircraft's tanks.

Specification for Fuel

The specification finally arrived at for jet fuel should be as broad as possible to insure low cost and wide availability, without compromising safety or aircraft performance. The airlines suggest, for example, that for kerosene the allowable gravity spread be widened if possible beyond the limits tentatively proposed so that transports can use lighter kerosenes available in certain areas outside the United States.

The specification should not penalize the less fussy engines to satisfy the needs of the most critical engine.

Any requirement that adds to the cost of turbine engine fuel will be scrutinized carefully. An increase of 1¢ per gal, United Air Lines estimates, would increase its direct operating cost 2.4%—or $1,750,000 a year. While the airlines grant that special higher-priced aviation gasolines for piston engine transports paid off in added payload and performance, they doubt that some of the special turbine fuels which have been proposed would be economically justified.

Table 3—Factors Affecting Fuel System Icing

1. Initial Fuel Temperature and Final Fuel Temperature
The temperature differential determines the amount of ice that can be generated. The final fuel temperature determines the severity of icing, since heavy icing appears to be confined to a relatively narrow temperature band.

2. Fuel Composition
Equilibrium dissolved water content is influenced by the fuel blend. Aromatics tend to increase water content. Fuel viscosity and specific gravity effect settle-out rate.

3. Dissolved Water Content of the Fuel
This is a function of loading temperature, degree of saturation, and environmental conditions.

4. Rate of Fuel Cool-Down
A rapid cool-down (1 to 2 hr) is conducive to small water particle size (4 to 10 microns in diameter). A slow cool-down tends to form larger water particles on the order of 15 to 40 microns. The smaller particle size tends to block filters and screens more rapidly.

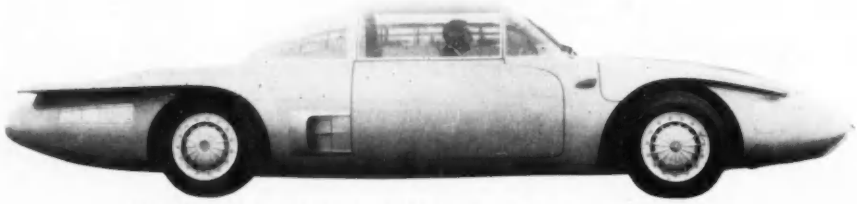
5. Fuel Flow Rate
This determines the time required to ice a component when all other conditions are equal.

6. Humidity Above the Fuel
If the fuel is low in water content it can pick up moisture from a humid atmosphere; the reverse process also occurs.

7. Flight Duration
The total ice accumulation is a function of total fuel flow through the system, and therefore, is a function of flight duration. Operating time also influences water content as a function of settling time and time to reach equilibrium with its environment.

8. Presence of Nucleation Sites
The water particles remain liquid even at extremely low temperatures until a surface or nucleus is provided to form an ice crystal. On many occasions traces of dust and iron oxides are found in the ice. One theory is that these impurities serve as nuclei for the ice formation.

9. System Geometry
Component design influences ability to ingest ice without malfunction. The system geometry will play an important part in determining icing characteristics.



The XP-500 in which the GMR 4-4 Hyprex engine is installed.

GMR 4-4 HYPREX Free Piston

A. F. Underwood,

Head, Mechanical Development Department, Research Staff, General Motors Corp.

Excerpts from paper "A Concept of the Free Piston Engine for Automotive Use" presented at SAE Summer Meeting, Atlantic City, June 5, 1956.

GENERAL MOTORS Research Staff has designed a 250-hp free piston gasifier-plus-turbine engine and installed it in a passenger car. (The car will be described in the July issue of SAE Journal.)

Analysis and results indicate definitely that the engine will be a serious contender for powering automotive vehicles.

The gasifier raises the pressure and temperature of the air it takes in. In this respect it is roughly comparable to the combination of compressor and burner in the conventional gas turbine powerplant. But the gasifier has one outstanding advantage: **The gases it discharges enter the turbine at a temperature several hundred degrees cooler than would the gases from the burner of a comparable conventional gas turbine powerplant.**

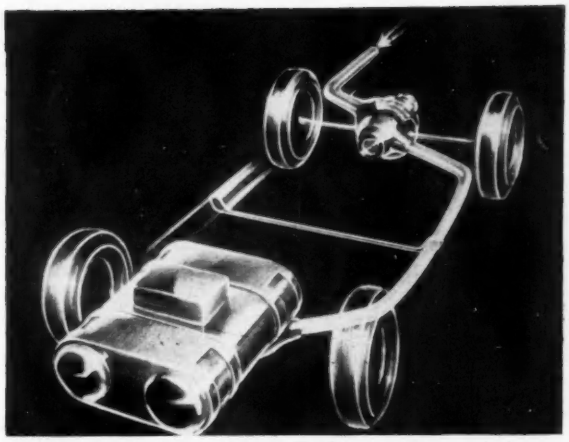
The gasifier is basically a uniflow two cycle diesel engine with a built-in air piston compressor for scavenging purposes. Considering only the two power pistons, they function in the same manner as the opposed piston type of two cycle diesel engine. The exhaust and intake ports are uncovered at the end of each stroke. At this time the compressed air from the air box blows through the diesel cylinder, reducing the temperature of the engine parts and scavenging the combustion chamber for the next portion of the cycle. Fuel is injected by a standard type of injector when the pistons are approximately at their inner dead point. The explosion forces the two pistons apart in the usual manner. All of the mechanical energy for the cycle is developed during the expansion of the gases between the pistons. A simple linkage, consisting of a parallelogram, keeps the two power pistons in phase. This linkage has very little force to transmit because it is required only to take care of differences in friction of the pistons, and such components as the fuel injector and controls.

In the usual diesel engine the air for scavenging is supplied by a mechanically driven blower or by a turbocharger. In the case of a free piston engine the scavenging air is obtained by the large air compressor pistons which are directly attached to each of the power pistons. The reciprocating motion of the air pistons draws air in through the intake valves on the outward motion of the pistons and forces the air into the air box through the delivery valves during the inward movement of the pistons.

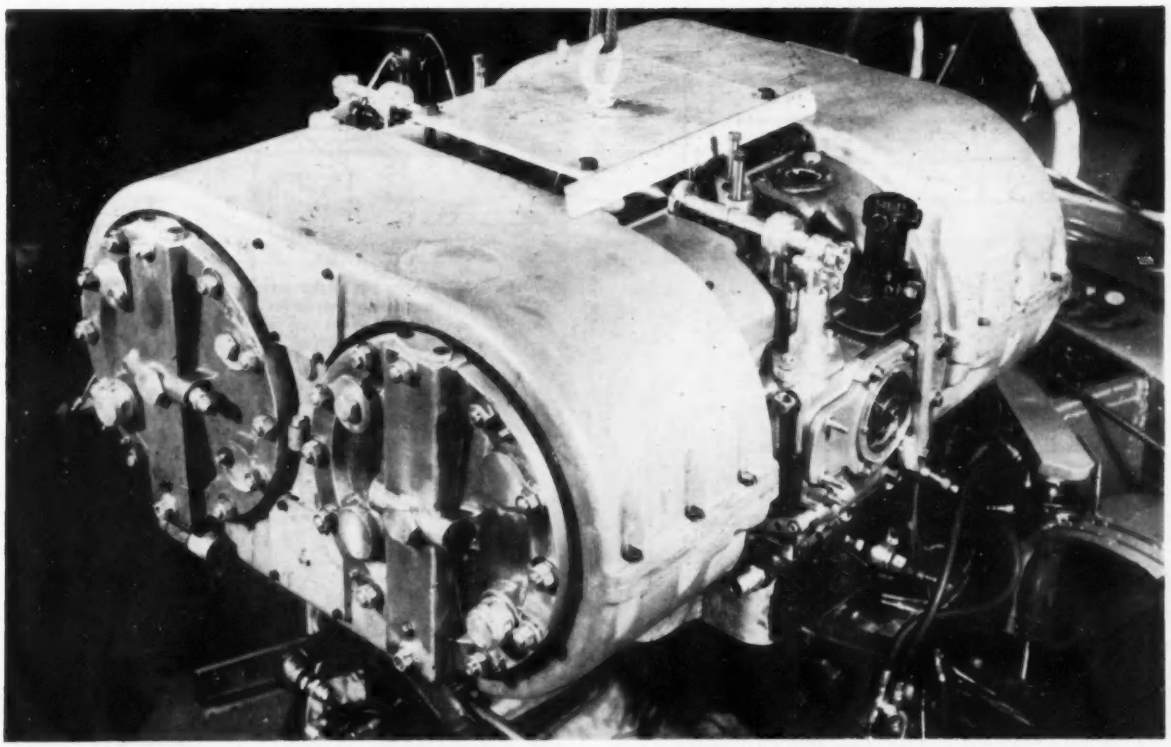
This feature of the free piston engine results in the relatively low turbine inlet gas temperature. To understand why this is so, let us start with the burning of the fuel in the highly compressed air of the combustion chamber. As it expands, energy is used (1) to compress the air in the bounce chamber and (2) to draw air into the large air compressor cylinder. These energies are transmitted by the piston assembly. Now, when the bounce chamber returns the piston assembly, the energy for delivering the compressed air to the air box comes from the energy which was stored in the bounce chamber and which in turn had come directly from the expanding gases after combustion. Therefore the energy for compressing the scavenging air into the air box was extracted mechanically from the gases within the combustion chamber. This transfer of energy means that exhaust gases coming from the exhaust ports (when they are uncovered) have been reduced in temperature. In addition there is mixing

CONTINUED ON PAGE 62

Turbine Engine



Gasifier goes in front of car. Turbine and transmission go in rear. Gasifier's exhaust is ducted through frame to turbine. Result: Weight is desirably distributed. No humps for transmission or propeller shaft are needed in floor.



FREE PISTON TYPE TURBINE ENGINE includes a gasifier shown above which raises pressure and temperature of air and a turbine to take energy out of the air. Basic concept of the engine is over 30 years old. Many engines in 1000-hp class have been built for ships, locomotives, and power stations, and some gasifiers are used alone as air compressors.

But powerplant built by General Motors Research Staff differs in that it is small, light weight, and has a power/weight ratio high enough for automotive use. It is the first powerplant to have a siamesed gasifier, in which two cylinders—each with a pair of piston assemblies—share an air inlet housing and an air box for scavenging.

GM engine is nominally a 250 gas hp unit. Because of the low-speed characteristics of the gas turbine, it gives performance in a vehicle comparable to that of a 300 hp conventional piston engine.

Siamesed gasifier is 40 in. long, 34 in. wide, and 18 in. high. Maximum cyclic speed is 2400 strokes per min. Minimum speed can be of the order of 1000 cpm. Specific fuel consumption under 0.45 lb per gas hp-hr was obtained during early testing. Value is expected to reach 0.40 soon. Further development can well bring it to under 0.36 lb per gas hp-hr.

with the excess scavenge air blowing through the combustion chamber, causing a lower exhaust temperature. These exhaust gases are, of course, piped to the power turbine and therefore are the reason for the low turbine temperature.

In a combustion turbine, the energy is also produced in a combustion chamber. However all of the energy is directly transferred to the power turbine by high temperature gas. Here, the energy required for the air compressor is extracted and fed back to the compressor turbine. If separate compressor and power turbines are used, the compressor turbine is subjected to the temperature of the high energy gas, even though only the compressor energy is extracted.

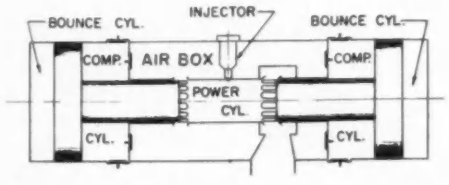
The important conclusion is that (1) in the free piston engine-gas turbine, the power turbine receives **low** temperature gas because the work of compressing the air has been removed, whereas (2) in the combustion turbine, the power turbine receives **high** temperature gas because it must produce the added energy to compress the air.

The air intake and delivery valves are of the reed type. Mechanically operated valves cannot be used in a free piston engine because of the variable stroke, and their added complication would add nothing to the efficiency of the cycle.

The bounce chambers at either outer end of the compressor pistons absorb energy from the expanding gas in the power cylinder while the pistons are moving towards their outer dead point. In effect the bounce chambers can be thought of as air

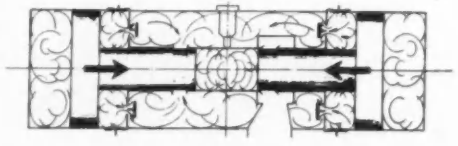
How the Free Piston Gasifier Works . . .

1.



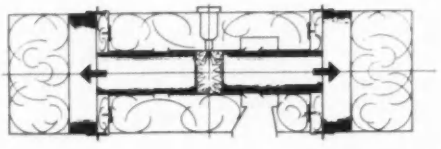
Pistons in starting position. Intake and exhaust ports open. All valves closed.

2.



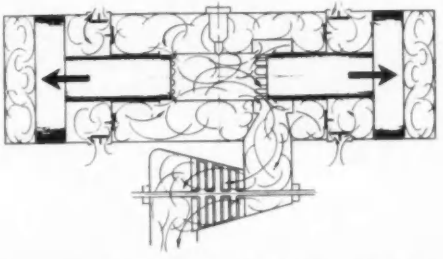
Starting air pressure is admitted to bounce cylinders. Pistons move inward, closing ports, compressing air in power cylinder, and forcing scavenging air from compressor cylinder into air box.

3.



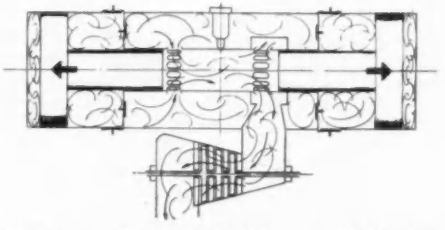
Pistons complete inward travel. Fuel is injected into power cylinder. Combustion starts and power stroke begins.

4.



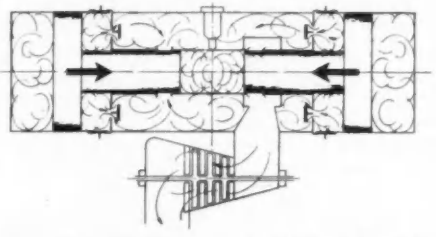
Pistons continue outward travel. Air in bounce cylinders is compressed to store energy for return stroke. Compressor intake valves open. Exhaust ports open and gas is admitted to turbine.

5.



Further outward movement of pistons opens intake ports, completing power stroke. Air from air box scavenges power cylinder and escapes to turbine.

6.



Pressure in bounce cylinder moves pistons inward, starting next cycle.

springs. The energy contained in the bounce air at the outer dead points is used to compress the scavenge air into the air box and to compress the air in the power cylinder for the next explosion. The rate of the "air spring" in the bounce chambers is effectively controlled by the amount of air which is in the bounce chamber.

Stabilizer Changes Engine Speed

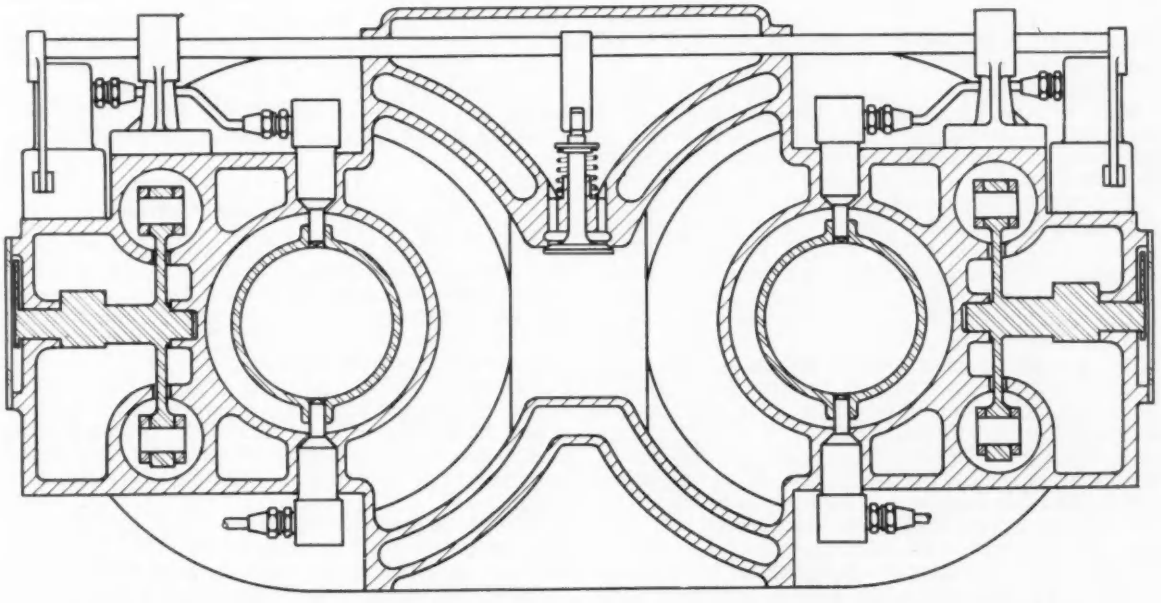
The speed at which a free piston engine operates is determined by the mass of the moving parts (primarily the air pistons and the power pistons) and the spring rate of the bounce chambers. Therefore to change the speed of a free piston engine it is necessary to adjust the amount of air in the bounce chamber. This is accomplished by a device which has become known as the stabilizer.

The stabilizer is essentially a two-way air valve which allows air to be transferred from the bounce chambers to the air box. During one complete cycle there are times when the air box pressure is higher than the instantaneous bounce chamber pressure, and there are times when the reverse is true. If now it is desired to increase the speed of the engine, then the stabilizer functions to allow an appropriate amount of air to enter the bounce chamber from the air box. This increases the spring rate and causes the mass of the pistons to operate at a higher frequency. By removing air from the bounce chamber, the engine is slowed down.

A simple free piston engine will not produce less than about 25% of full load. Until recently it was necessary to discharge part of the exhaust gas to the atmosphere if it was desired to operate the power turbine at less than 25% load. Obviously this was a very inefficient situation and resulted in extremely poor part-load economy. As an example, the early models of free piston engines required about one-fourth of full-load fuel rate for idle. In other words, the free piston engine was as inefficient as the non-regenerative combustion gas turbine.

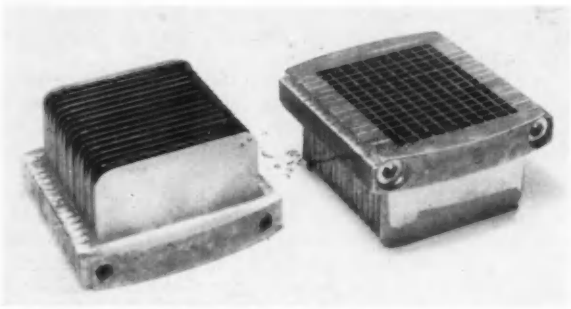
Recirculation Improves Idle Efficiency

Today a method known as "recirculation" is employed to improve the part throttle and idle efficiency. This is simply the action of bypassing part of the air in the air box back to the air intake of the compressors. The effect of such recirculation is to heat up the incoming air, resulting in two improvements. First, it raises the temperature of the air in the combustion chamber at part throttle and idle, thereby allowing combustion at lower compression ratio. The lower compression ratio (10 to 1) is the result of reduced stroke, primarily an increased



SIAMESED GASIFIER with dephased cylinders allows one cylinder to be scavenged while the other power piston assembly is compressing scavenging air into common air box. Result is less pumping loss than when ducts are added to permit outward moving piston to furnish scavenging air for its power cylinder. Siamesing allows more compact design, more even flow to turbine, and probably quieter engine operation.

The two cylinders have a common air inlet housing, a common air box for scavenging, and a closely siamesed exhaust outlet. Power cylinder is 4 in. in diameter. Air compressor piston is 11 in. in diameter. Stroke is approximately 5 in.



INLET VALVES AND EXHAUST VALVES are identical. There are eight inlet valves and six delivery valves for each air compressor. (Previous tests have indicated that reed type gives highest operating speed and best volumetric efficiency.) Design is such that bodies can be die castings and blades simple steel stampings. Valves are completely satisfactory at present. But development will continue and is expected to allow increased cyclic speeds, better efficiency, lower production cost, and optimum numbers of reeds.

---

spread between inner dead points. A softer cushion under these conditions in turn reduces the speed, and consequently there is much less power and fuel consumption is reduced. Secondly, it reduces the air being pumped by the engine, and therefore a dump valve to the atmosphere at low loads is not required. On certain free piston engines now in use, fuel consumption at idle has been reduced to 8% of full throttle fuel requirements.

The quantity of air pumped by the gasifier to the turbine is determined by several factors. The first factor is the speed of the engine, which is determined primarily by the mass of the parts and the spring rate in the bounce chambers. The second is the variable stroke. A relatively small change in the effective stroke of the pistons produces a large difference in the pounds of air pumped by the gasifier. The difference between minimum outer dead point and maximum outer dead point can make a difference of 45% in pounds of air pumped per minute. The rate of fuel injection is the primary stroke regulator, especially in its effect on outer dead point. Bounce pressure is the secondary stroke regulator, affecting primarily the inner dead point, but also affecting the outer dead point.

One of the functions of the stabilizer is to insure that the air pressure in the bounce chambers is at the proper value consistent with the amount of fuel injected each stroke, to make the engine operate within the desired stroke limits. If, for example, the air pressure in the cushion is too low compared to the amount of fuel which is injected, then the engine will overstroke and the pistons will hit against some part of the engine. If the air bounce pressure is too high for the amount of fuel which is injected, the engine will understroke and stop running.

Since there are no rotating parts as in a crankshaft or a gas turbine engine, the fuel injector is operated by the linkage which connects the two piston assemblies. Because the linkage is not moving at the inner dead point, which is approximately when injection should occur, it is necessary to employ either a high rate cam if mechanical injection is to be used, or to utilize an accumulator system which can be tripped at the proper time.

In actuality this engine operates at a variable compression ratio. For example, when the air box pressure is one-half atmosphere, the compression ratio is in the neighborhood of 25 to 1. At full power when the air box pressure is 3 atmospheres, the compression ratio approaches 50 to 1. Under the latter conditions the compression pressure is of the order of 1200 psi and the firing pressure is under 2000 psi. As would be expected, the temperature and pressure prevailing in the combustion chamber under these conditions are so intense as to cause effective and efficient combustion. The result is high efficiency in the burning of fuel. Also these conditions are the reasons for the relative insensitivity of the free piston engine to the quality and character of the fuel. The completeness of the combustion has been demonstrated by the tests which we have made for thousands of hours on one engine, with no appreciable deposits in the ports or exhaust pipes, even on Bunker C fuel.

The turbine in this cycle acts as a fixed orifice. At least this is true for the first approximation. Therefore the air box pressure of the gasifier is effectively equal to the pressure drop through the turbine plus the pressure drop through the power cylinder (including intake and exhaust ports) plus the loss in the piping connecting the gasifier to the turbine. The turbine recovers a large percentage of the energy put into the compressing of the scavenge air, which is another factor for the high efficiency.

Reasons for a Siamesed Gasifier

The most novel feature of the concept of the General Motors free piston gasifier is that it is a siamesed unit. By siamesed is meant a common case for two complete cylinder assemblies, a common air box, a common air inlet housing, and a common exhaust. This configuration was selected after careful consideration of the many types of possible designs. (Siamesing differs from twinning. Twinning is accomplished merely by running the exhaust from two gasifiers into a common header and dephasing the two machines by an appropriate pneumatic device.)

One of the principal differences of opinion among free piston engine engineers is whether the engine should be an outward compression type or an inward compression type. This terminology refers to whether the air compressor pistons compress the scavenging air into the air box during the inward movement of the piston assemblies or during the outward movement of the piston assemblies.

In the case of a single-cylinder outward compression gasifier, the engineer finds an improvement in efficiency over an inward compressing type. This is brought about by the fact that the outward compressing engine supplies its air to the air box during the time when the exhaust ports are open and the

engine is being scavenged. The result is a lower pumping loss and, therefore, a small percentage gain in overall efficiency. The disadvantage of an outward compressing machine is that external air pipes must be added to conduct the compressed air from the ends of the machine to the air box. Also in order to get good control of the engine speed, the bounce chamber is usually added on to the end of the air compressor cylinders. This results in an overall increase in the length of the machine.

The inward compressing type has the advantage of smaller dimensions both in length and height. Another real asset is the comparative ease with which such a machine can be assembled and disassembled for inspection. Therefore it is obvious that if the inward compression engine can be made to give the slightly improved thermal efficiency of the outward compression engine, the arrangement would be one which combined the better points of each configuration. The siamesing accomplishes this because with dephased assemblies in a common case, one cylinder is being scavenged while the other power piston assembly is compressing the scavenging air into the common air box.

Another important advantage of the siamesed design is the compactness of the engine for a given horsepower and the more economical use of space—particularly if one considers the volume under the hood of a passenger car. It is obvious that a single cylinder engine of the same horsepower as a siamesed unit would have to be considerably longer. This can be demonstrated by the preliminary design of a 250 hp engine based on a single cylinder. It was projected to be over 60 in. long. By twinning, the same horsepower output could be attained in an overall length of 40 in. Less engine noise would be expected from siamesing due to more even air intake pulsations and to having two cylinders firing at regular intervals.

While there is currently no definite information on the effect of the pulse discharges from the gasifier on the efficiency of the gas turbine, it is believed

Advantages of the Free Piston Type Turbine Engine

The free piston gasifier combined with a gas turbine has these advantages:

1. **It is not sensitive to fuels.**

   It will run on kerosene, No. 2 diesel oil, or Bunker C. It will even run on whale oil, peanut oil, or cottonseed oil. Even with sulfur content as high as 4%, the gasifier can operate satisfactorily for tens of thousands of hours.

2. **Overall efficiency is high.**

   With compression ratio of 30–50 to 1, gas is generated at 40–45% efficiency at full load. With a turbine efficiency of 80%, this gives an overall thermal efficiency of 32–36%. The free piston plus turbine combination is competitive both at full load and at part load, with the high compression gasoline engine and the diesel engine in efficiency.

3. **Free-piston engines run smooth.**

   The free piston gasifier is inherently balanced.

4. **The turbine produces high torque at low speed.**

   A simple two-step transmission may be satisfactory to match the performance of current transmission drives.

5. **Gas entering turbine is relatively cool.**

   Temperature is 450–900 F. So turbines can be made of readily available, plentiful alloys. Alloys such as Silchrome #1, containing only chromium and silicon as alloying elements, can be used instead of alloys requiring such scarce alloying elements as nickel and columbium. Also, the relatively low turbine temperature means that elements in the fuel such as vanadium compounds will not cause harmful corrosion of the blades.

   The power gas is at a lower temperature than the exhaust gas of a gasoline engine, even at full load. The power can readily be piped from one part of the vehicle to another. The gasifier can be placed where it is most convenient from weight or space considerations. The turbine can be located near the wheels.

6. **Response to throttle is prompt.**

   The gasifier can increase, decrease, or stop its flow of gas very rapidly.

7. **Power can be augmented by adding an afterburner.**

   This would be done between gasifier and turbine. The gas from the gasifier still has 80% of its original oxygen. Addition of fuel in an afterburner to the gas makes almost instantaneous increased power available. This feature is particularly desirable in a vehicle where acceleration and peak power may be needed for short periods.

8. **The free piston gasifier plus turbine combination suits all types of vehicles.**

   A family of engines can be derived from the basic building blocks. The components can be produced on tools similar to those used for crankshaft engines.

desirable to have as uniform a gas pressure as possible at the turbine inlet. The current practice with single cylinder engines is to include an exhaust gas receiver to minimize the pulsations. A siamesed unit does this without the use of a large exhaust receiver.

The steel pistons are of a conventional design with heat dam and oil cooling. The oil for this purpose is also used for general lubrication of the engine parts such as the connecting linkage. Lubrication for the power pistons is provided directly to the cylinder walls and indirectly from the air compressors. The wear bands on the piston are made of aluminum coated steel. Tests on a larger engine indicated that the one component which was affected by sulfur in the fuel, was the copper lead coated wear bands. By the use of the special aluminum alloy, during several thousands of hours of testing, it has been demonstrated that there is no chemical attack.

A separate fuel injection pump and nozzle are used for each cylinder. The pump is actuated by a cam on the linkage mechanism. As with all free piston engines it is essential to inject rapidly at the correct time because the pistons accelerate rapidly from their inner dead point. The high acceleration is the result of having to accelerate only the piston assemblies, whereas in a standard piston engine the inertia of the crankshaft and flywheel restrain the pistons from moving as rapidly just after top dead center.

The successful operation of a siamesed unit is dependent on the dephaser. Its action is to keep the two piston assemblies 180 deg out of phase. The pneumatic device used on this engine obtains its signal from the bounce chamber pressures. In general, the action is to accelerate or retard the cyclic speed of one piston assembly, in relation to the other piston assembly, in order to maintain the proper timing. The dephaser has functioned satisfactorily from the beginning of our siamesed engine test and has been a strong reason for our confidence in this design of an engine. Actually the engine starts in parallel operation and then within a few strokes is forced into dephased operation.

The starter follows the usual practice of putting the pistons into a proper position near their outer dead points. Quick admission of air into the bounce chambers suddenly forces all of the pistons to their inner dead points compressing the air in the combustion space. Fuel is injected, combustion takes place, and the piston assemblies are accelerated outward. Then the control mechanisms must take over and determine promptly the correct cushion pressure for the amount of fuel which is being injected so that the engine will not understroke nor overstroke. As with all free piston engines of the inward compression type it is essential that proper firing be present on the first stroke as there is no carryover of inertia for a second stroke.

Second Stroke Most Critical

The most critical stroke is the second, as the controls must "take over" and adjust the bounce pressure in relation to the injected fuel or the engine will stop. In other words, if the engine does not start on the first stroke and if the controls do not properly regulate thereafter, it is necessary to go through the starting steps again. Air pressure for starting can be obtained from air bottles or by an air compressor of sufficient capacity to furnish the air directly for each start. Air pressure of 30 psi in the bounce chamber is adequate to start this engine.

Turbine

The present gas powered turbine is a five stage axial flow unit. Its stall torque characteristics are those which are normally found in such a turbine, and as would be expected, the turbine gives excellent torque multiplication in itself. The power output from the turbine is through a gearbox having a reduction ratio of approximately 7 to 1.

The gearbox is bolted directly to the front of the transmission. Since the front elements of the transmission are running whenever the gasifier is in operation, certain accessories such as the electric generator, power steering, and water pumps are driven directly from the transmission.

The turbine on the XP-500 is the first one we have ever made for a gasifier. However it has shown an efficiency of about 70%, and very fortunately this efficiency is maintained over the speed range for the load requirements of the automobile. That is to say the efficiency when running at light load and low speed is the same order as when running at high load and high speed.

As with all turbine installations the torque multiplication gives increased performance over the crankshaft engine of the same nominal horsepower. Another way of expressing this is to say that the transmission engineer has a new opportunity to develop a simpler transmission which utilizes the special characteristics of the gas turbine.

Acknowledgments

To carry the conceptual design of the free piston automotive engine to an evaluation in a few months required the experience, skill, and continued interest of a large number of persons. The design of the gasifier and the reduction gears was under the supervision of Warren H. Smith. Invaluable consultation was had from Robert Huber, S.E.M.E., who made the basic engine design to conform to our requirements and specifications. The turbine was furnished by W. A. Turunen, Gas Turbines Department. Construction of the chassis was under the supervision of Joseph P. Bidwell, Engineering Mechanics Department, and the body had the personal attention of R. McLean, Styling Section. The special transmission was provided by Oliver K. Kelley, Engineering Staff.

Especial acknowledgment is made of the effort and contributions of Gregory Flynn, Jr. who has been associated with the project during its entire development, and who has coordinated the project work. General supervision was the responsibility of Worth H. Percival, with particular reference to construction and testing.

Each of the many engineers, designers, and mechanics who participated in this program deserve credit for their interest and their work.

Complete paper on which this abridgment is based is available in full (in multilith form) from SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

Many engineering advances are taking place in the field of processing. Here are three examples which may become . . .

. . . Processes for Tomorrow

T. R. Linton, Bohn Aluminum and Brass Corp.

Based on secretary's report of panel discussion on "Materials and Processes for Tomorrow" held at the SAE Summer Meeting, Atlantic City, June 13, 1955.

Vacuum Metallizing

VACUUM metallizing plates small metal or plastic parts with a thin coat of metal which is hard, durable, and economical, to improve their appearances. The success of the process, however, depends on proper application of a lacquer film prior to metallizing.

The parts are first lacquered. They are then placed in a vacuum cylinder where an evaporation-condensation process plates the parts with a thin coat of metal. A final coat of lacquer is then applied to the plated parts.

The basic vacuum metallizing unit consists of a horizontal or vertical steel cylinder. (The horizontal cylinder seems to be preferred because it permits easier removal of the load.) The chambers vary in size from 30 in. in diameter to 72 in. in diameter and are usually 60 in. in length. The parts to be coated are mounted on suitable racks and placed within the chamber. The door is closed and the cycle started.

Pumping systems are mounted near the unit and provide the high vacuum obtained within the chamber. When a vacuum of 0.5 microns has been obtained, the metal to be used for plating is heated to incondescence by resistance heating of a tungsten filament or a molybdenum crucible. Further raising of the temperature causes the metal to evaporate and condense on the surfaces of all the parts exposed within the chamber.

Since the metal vapors travel only in a straight line, rotation of the parts is necessary if all surfaces of the parts are to be plated. This rotation is achieved by means of a driveshaft with a high vacuum rotary seal extending through the end of the chamber and driven by a motor which is mounted externally.

The metal that is usually deposited is aluminum because it is the cheapest metal to use and can be most easily evaporated. Tungsten filaments, similar to the filaments in the conventional electric light bulb, although somewhat heavier, are used to hold small aluminum wire staples. These staples are about 0.06 in. in diameter and about ½ in. long.

The staples are hung on the tungsten filaments. When the proper vacuum has been obtained, current is passed through the filaments, causing the aluminum to melt and wet the entire surface of the filament. Further heating evaporates the aluminum, thereby coating all of the parts in the chamber.

Because the aluminum film is very thin—about 0.000005 in.—it exactly reproduces the surface on which it is deposited. So, to achieve a simulated polished surface, a coating of lacquer must be applied to the surface of the item being metallized before the metal film is applied. This lacquer coating serves as a sealer to prevent outgassing of plas-

Serving on the panel on Materials and Processes for Tomorrow which developed the information in this article were:

Panel Leader

W. E. McCullough, Bohn Aluminum and Brass Corp.

Panel Secretary

T. R. Linton, Bohn Aluminum and Brass Corp.

M. E. Nevins, Wisconsin Centrifugal Foundry, Inc.

H. J. Hamjian, Utica Drop Forge and Tool Corp.

J. G. Seiter, F. J. Stokes Machine Co.

L. F. Swoboda, Kaiser Aluminum and Chemical Corp.

tic items and provides a glossy surface which will fill in minor mold defects on the surface of plastic parts, zinc die castings, or steel stampings.

Application of the lacquer film represents the greatest problem in the metallizing process. It is necessary to have almost perfect lacquer coating to achieve the desired results. There can be no runs, orange peel, sags, dry areas, or such.

There are three general techniques in wide use today for lacquering. The first method is the conventional spray method which may either be hand or electrostatic application. Hand spraying requires considerable skill and technique. Electrostatic spraying is excellent in many applications although there are certain disadvantages if the shape of the piece is such that the lacquer will not reach all surfaces.

A second method of lacquering is by dipping. Dipping is done in either of two ways: by slowly withdrawing the parts from the lacquer tank to eliminate runs, or by rapidly withdrawing the parts from the tank, spinning them to remove excess lacquer, and then slowly rotating them to even out any runs. Both methods require a considerable investment in lacquers. Continuous filtering of the lacquers is recommended for both methods, to remove any foreign particles which might otherwise lodge on the final film.

The third and most popular method is known as flow coating. The parts to be metallized are first mounted on appropriate racks, called "spiders," and then placed in a tank. Lacquer is pumped through a centrifugal pump and a filter to a manifold containing several spray nozzles mounted above the spider. The spider is slowly rotated while the clean lacquer cascades over the parts to be coated.

After the parts are thoroughly washed with the filtered lacquer, the lacquer supply is shut off and the spider is spun rapidly to remove any excess lacquer. The entire spider is then transferred to a rotator which revolves the spider at approximately 8 to 10 rpm for a 10 or 15 min air dry. This rotator evens out any lacquer runs and provides a smooth, glossy coat of lacquer which will receive the metal vaporized in the metallizing chamber.

The base coat of lacquer must be baked. For most plastics, baking time is about 1½ hr at a temperature of about 150 F. The top coat of lacquer, which is applied after metallizing, is either air dried or "quick baked" for 10 or 15 min at 150 F. With metals, the base coat is usually baked for ½ hr at 300 F, and the top coat receives a similar treatment.

After the top coat of lacquer has been applied, and baked for 10 min, the finish of the zinc die casting, steel stamping, or plastic part is similar to polished chrome plating. It is then possible to dye the top coat of lacquer in a water soluble dye to achieve any desired metallic effect. Copper, gold, bronze, brass, can all be achieved readily with a few seconds of immersion in the dye dip tank.

After dyeing, the parts, still mounted on the original spider, are rinsed in water, then rinsed in a mild detergent which eliminates any water spots. And then again the parts go into the baking oven. This sets the color.

Vacuum Melting of High Temperature Alloys

MAKERS of high temperature alloys are melting the constituents in a vacuum instead of under the usual free atmospheric conditions. The process produces high temperature alloys having properties superior to those attainable with air melting techniques. In addition, these processes enable the salvaging of air processed scrap.

To obtain maximum stress-rupture strength in steel alloys containing aluminum and titanium, these elements must be controlled within a range of 0.1%. The reactive nature of these elements makes it very difficult to melt in air without losing a large percentage to oxides and nitrides, resulting in a weak, dirty material.

Vacuum melting appears to give the necessary control to produce high strength alloys of this nature.

Another advantage of vacuum melting is the salvaging of unacceptable air processed material by proper dilution, alloying, and refining techniques. Such scrap has been remelted under vacuum with the result that stress-rupture life at high temperature increased to five times that of the air melted material.

Centrifugal Casting of Titanium Alloys

TITANIUM alloys are centrifugally cast by spinning the molten metal in cylindrical molds.

Centrifugal casting of small titanium alloy parts has been a reality for the past year. The lack of a

Table 1—Comparison of Properties of Cast Titanium and Forged Titanium

Centrifugally Cast Material	Tensile Strength, psi	Yield Strength, psi	Elongation, %	Reduction in Area, %
Ti(106 BHN)	52,000	42,000	42.0	66.0
7 Al—3 Mo[a]	136,000	122,000	10.0	12.4
6 Al—4 V[a]	137,000	129,000	7.0	17.6
Ti—155 AX[a]	160,000	150,000	12.0	14.7
Forged				
Ti(106 BHN)	50,000	40,000	45.0	70.0
7 Al—3 Mo[a]	160,000	140,000	10.0	15.0
6 Al—4 V[a]	140,000	130,000	11.0	38.0
Ti—155 AX[a]	160,000	135,000	10.0	15.0

[a] Heat-Treated

suitable mold material, however, makes difficult the manufacture of large castings.

A typical titanium alloy melting and casting unit contains a water cooled, copper shell furnace. This is commonly known as a skull type melting furnace. A tungsten tipped, water cooled, nonconsumable copper electrode may be used to melt the alloy.

Or a consumable electrode may be substituted for the nonconsumable electrode in this process. With the consumable electrode, previously melted titanium is its own electrode. The electrode is inverted so that as the metal melts it drops off and forms a molten pool similar to that in a welding operation.

The casting machine is a conventional type but uses graphite molds because this seems to be the only material that stands up in the process. The big problem is in procuring molds above 35 in. in diameter. This condition will have to be remedied if larger titanium alloy castings are to be made.

Table 1 compares the properties of the centrifugally cast titanium alloys with those of the forged alloys.

Fuselages . . .

. . . of coming higher speed aircraft will have larger, integrally stiffened skins and better sealing. Hydrostatic testing is key to solving problems of fatigue failures.

Based on panel secretary's report by **K. R. Derryberry,** Douglas Aircraft Co., Inc.

STRUCTURAL failures due to fatigue may produce results which range from minor to catastrophic. Such fatigue failures of fuselages can be divided into four categories:

1. Vibration of panels. This sometimes occurs in the skin and supporting structure of the landing gear doors which have been subjected to buffeting. Sonic vibrations can also cause failure.

2. Joint deflection. Skin failures may occur because of splicing heavy members such as longerons in a location where the skin is continuous. Possible cures are to splice both members or, more efficiently, taper slice members. Close fit on fasteners helps to prevent joint deflection.

3. Stress concentration. Members should be tapered with no abrupt change in section. Sharp radii should be avoided in stressed members. Cutouts should have generous radii as well as adequate reinforcing to reduce stress concentration.

4. Failure of fasteners. There is an important item in body skin splices which fatigue-wise are very much affected by the type of fastener used. It is necessary to determine whether to use spotwelds or rivets and, if rivets, whether to use countersunk or dimpled holes. The number of fasteners becomes important since fatigue life is affected by the load per fastener.

Testing is the most important tool available for learning about fatigue and designing for a satisfactory life. Hydrostatic testing has been used on completely submerged structures. With this method when failure does occur, it is not explosive and the location of the original failure can be observed.

Fatigue in structures often starts as a nick or scratch. Hence they must be eliminated. Good inspection is imperative. It provides the designer with valuable information, and time and again it has prevented catastrophes.

To prevent catastrophic failure due to fatigue, four points are essential:

1. Design so that the loss of one member shall not cause loss of the airplane. The structure shall "fail safe."
2. Provide dual paths for tension stresses in critical members. This is one way to design around the problem.
3. Avoid fasteners by using forgings whenever possible in complicated joints.
4. Use longer members or bigger panels in body skins when possible so as to avoid splices.

A look into the future tells us that faster, higher flying aircraft will require better sealing and that the trend will be toward larger integrally stiffened skins. Sealing will become more specialized and employ more highly trained personnel. There will be better allocation of time and space for sealing and drying, and more protection from metal chips. Automatic equipment will be used more widely, and equipment for checking leakage will be improved.

We can look for radically new sealing techniques such as channel sealing—that is, machining grooves in material, then forcing in the sealant.

Watch for V-type windshields in the cockpit enclosure area with its inherent problems of contoured glass and stress. All forward glass will be flat nesa panels, providing better optics and fit. Pilots will be able to see around all posts and each post will be machined flat. Glass will slide in at top so that all tolerances will accumulate at the bottom. Dummy glass will be used for pressure test with final installation of glass at the flight line. All sealing will be done from the outside, with no beading inside or out.

(This article is based on the secretary's report of panel on "Fuselages" held at SAE Golden Anniversary Aeronautic Meeting Production Forum, Los Angeles, Oct. 12, 1955. Leader of the Panel was C. A. Bower, Douglas Aircraft Co., Inc.; panel coleader, T. S. Crispin, Douglas Aircraft Co., Inc.; secretary, K. R. Derryberry, Douglas Aircraft Co., Inc. Panel members were: J. Adams, Lockheed Aircraft Corp.; J. S. Bergstrom, Convair Division of General Dynamics Corp.; C. Lindley, North American Aviation, Inc.; W. Sale, North American Aviation, Inc.; J. R. Watney, Boeing Airplane Co. This report together with 14 other panel reports are available as SP-313 from SAE Special Publications Department. Price: $2.00 to members, $4.00 to nonmembers.)

Differential Gas

. . . characteristics

THE differential gas turbine uses a differential to interconnect the turbine, compressor, and output shaft. Due to this arrangement, the differential gas turbine provides large output torques at low and zero output speeds, and maintains high turbine efficiency at low speeds while providing:

1. Up to 50% more turbine power at low output speeds than a two-turbine powerplant operating at the same compressor speed and fuel flow—enabling faster compressor acceleration than a two-turbine powerplant providing the same output power.
2. Fuel savings up to 65% of the fuel flow of a two-turbine powerplant operating at the same compressor speed and output power, or up to 35% of the fuel flow of a two-turbine powerplant operating at the same output torque and output power.
3. Reductions in compressor accelerating time of up to 65%, when compared with the two-turbine powerplant, in combination with good transient torque-speed characteristics.

Fig. 1 shows a simplified schematic drawing of the differential gas turbine. It shows the compressor and turbine mounted on separate shafts and shows the differential gearing for connecting these shafts to each other and to the output shaft. This is the same gearing arrangement as used in automobiles to enable the engine to transmit torques to both wheels while allowing their speeds to differ.

In the differential gas turbine, differential gearing enables a single turbine to transmit torque to both the compressor and output shafts while allowing the speeds of the compressor and output shafts to differ.

The turbine and compressor shown in Fig. 1 rotate in opposite directions. The turbine shaft is hollow and surrounds the compressor shaft extension. The ring gear of the differential connects to the turbine shaft and the pinion or sun gear connects to the compressor shaft. The planetary gears are free to rotate about their centers and as a unit to cause rotation of the low-speed output shaft. The ring gear is also free to rotate.

When the output shaft is held stationary, the planet centers are stationary and the planet gears act as idlers. At zero output shaft speed, the turbine drives the compressor at maximum compressor speed while rotating in an opposite direction at about half the compressor speed. When the turbine speed is increased to equal the compressor speed the planetary centers and low-speed output shaft are caused to rotate in the direction of the turbine shaft at about one-third of the turbine speed.

The planetary member may be considered as tending to rotate in the direction of the turbine because of the rotation of the ring gear and also tending to rotate in the opposite direction due to rotation of the sun gear. Because the diameter of the ring gear is larger than that of the sun gear, the planet centers and output shaft will rotate in the direction of the turbine when the turbine and compressor speeds are equal.

Reducing the turbine speed, while keeping compressor speed constant, reduces the output shaft speed. When the turbine speed is reduced to about one-half the compressor speed the pitch velocities of the ring and sun gear are equal, effectively canceling each other and providing zero output speed. Fig. 2 shows the shaft speed relationships. So, the differential turbine makes output speed a function of the **difference** between turbine and compressor speeds. A small change in turbine speed provides a large change in output speed.

In this typical example, the differential gearing serves to exert half of the turbine torque on the compressor shaft and the other half, multiplied by the torque multiplication of the gearing, on the low-speed output shaft. The differential, therefore, causes an approximately equal distribution of turbine power between the compressor and output shafts at the maximum output speed when the turbine and compressor speeds are equal. As the out-

David W. Hutchinson, President, The Turbex Corp., Mamaroneck, N. Y.

Based on paper "The Differential Gas Turbine" presented at the SAE Golden Anniversary Transportation Meeting, St. Louis, Nov. 1, 1955. Paper will be published in full in 1956 SAE Transactions.

Turbine . . .

meet ground vehicle demands.

put speed is reduced, a progressively larger portion of the turbine power is transmitted to the compressor shaft until at zero output speed all the power of the turbine is transmitted to the compressor shaft. This automatic variation in the division of turbine power between the compressor and output shafts has several advantages as will be shown.

Let's now examine what happens to the differential powerplant when the output speed is reduced at maximum compressor speed, maximum turbine inlet temperature, and maximum fuel flow. As the output speed is reduced, the turbine speed will reduce more gradually than the turbine of a single-shaft machine or the output turbine of a two-turbine powerplant, decreasing to about 50% speed

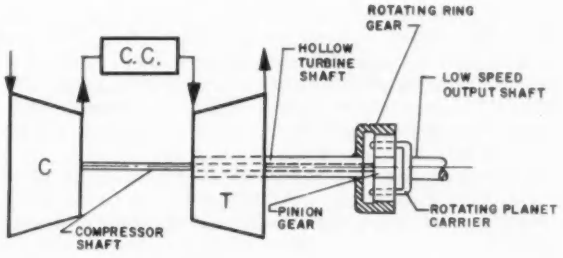


Fig. 1—Schematic of the basic differential gas turbine.

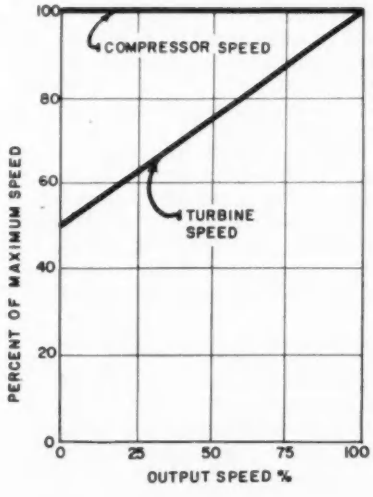


Fig. 2 (left)—Shaft speed relationships for a basic differential powerplant at maximum compressor speed.

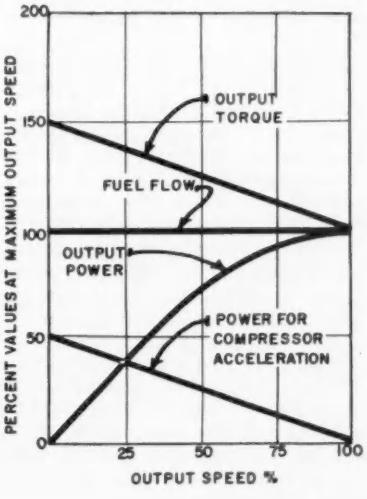


Fig. 3 (right)—The performance of a basic differential powerplant at maximum compressor speed and maximum turbine temperature.

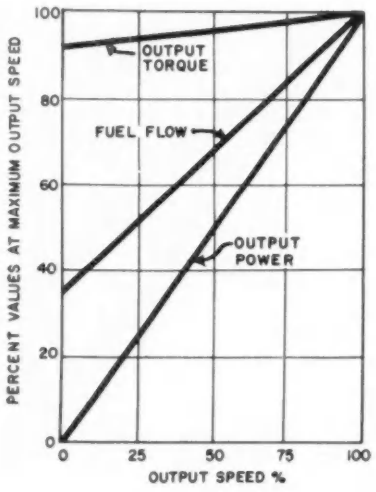


Fig. 4 (left)—The performance of a basic differential gas turbine at maximum compressor speed with no compressor acceleration.

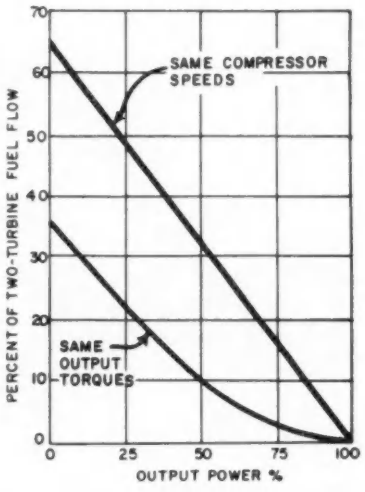


Fig. 5 (right)—Fuel savings of the basic differential gas turbine compared to a two-turbine powerplant providing the same output power.

when the output speed is zero, as shown in Fig. 2.

At one-half its maximum speed, the turbine is still operating in its efficient range and is capable of providing 75% of its maximum power at 150% of its maximum torque. The torque on the output shaft is, therefore, increased by 50% at zero output speed and there is a similar increase of 50% in the torque exerted on the compressor shaft. So, reducing the output speed to zero provides a 50% increase in power available to drive the compressor, which results in rapid acceleration of the compressor shaft.

Fig. 3 plots the output torque, fuel flow, and output power of the differential powerplant against output speed at maximum compressor speed and maximum turbine inlet temperature. Since the differential gas turbine provides large powers to accelerate the compressor and turbine, an additional curve showing the power available to accelerate the compressor is plotted in Fig. 3.

As the turbine of a differential powerplant operating at reduced output speeds and maximum fuel flow transmits more power to the compressor shaft than needed to drive the compressor, the fuel flow may be reduced as output speed is reduced with the turbine still providing enough power to keep maximum compressor speed. Fig. 4 shows the performance of a differential powerplant operating at maximum compressor speed at reduced fuel flows providing no compressor acceleration.

Note that when the compressor is not being accelerated, the differential gas turbine provides up to a 65% reduction in fuel flow as the output speed is decreased while still providing an output torque close to the output torque at maximum fuel flow. This represents fuel savings up to 65% compared to a two-turbine powerplant operating at the same compressor speed and output powers.

These large fuel reductions result because turbine power is reduced as output speed is reduced—but the turbine remains in its **highly efficient** operating range. The turbine efficiency is higher at low output speeds with no compressor acceleration than when providing acceleration. This is because the gas velocities are reduced as the turbine speed is reduced, keeping the ratio of gas velocity to turbine blade velocity very near the ratio giving optimum turbine efficiency.

In the powerplant discussed here, the turbine efficiency only dropped from 84% at maximum power to 77% at zero output speed. A similar reduction of the output speed of a two-turbine powerplant causes the efficiency of the output turbine to decrease to zero.

The differential powerplant can maintain a large output torque at the large fuel reductions at low and zero output speeds because the differential exerts a torque on the output shaft, due to the reaction forces of the gearing, without using any of the powerplant's available energy. The large standstill torques of the two-turbine powerplant, however, require using about half of the available turbine power in a stationary output turbine operating at zero efficiency. The elimination of loss of available energy and the high torque efficiency of the differential gas turbine make possible the large fuel reductions shown in Fig. 4.

The fuel savings of the differential gas turbine when not providing compressor acceleration and operating at the same compressor speed as a two-turbine powerplant are shown in Fig. 5. As shown in Fig. 4, these fuel savings are achieved at lower output torques than those of the two-turbine powerplant. Fig. 5 also plots the fuel savings of the differential powerplant while providing the same output torque and output powers as the two-turbine powerplant. In the latter case, the compressor speed of the two-turbine powerplant is reduced as the output speed is reduced providing a reduction in the fuel flow of the two-turbine powerplant.

Performance Comparison

A comparison was made of the overall performance of the basic differential and conventional two-turbine powerplants. Each powerplant was investigated for both steady-state and transient performance at three or more compressor speeds over a wide range of output speeds and output powers.

The steady-state performance was calculated

assuming fuel flow metered by a governor on the compressor shaft to maintain the compressor speed constant at each of the compressor speeds investigated. The transient performance was calculated assuming fuel flow metered by an acceleration control to provide a constant turbine inlet temperature of 1700 F during acceleration of the compressor. The results of these calculations are plotted in Figs. 6 through 8.

Fig. 6 shows the transient torque-speed characteristics of the two-turbine and basic differential powerplants at a constant turbine inlet temperature of 1700 F. The two-turbine powerplant provides up to 30% more output torque at low output speeds but the differential gas turbine provides much higher powers for acceleration at the low output speeds.

At this temperature, the two-turbine powerplant requires 7.1 sec to accelerate the compressor from 9000 to 13,900 rpm. As the output turbine of the two-turbine powerplant does not contribute to this compressor acceleration, the time required to accelerate the compressor is constant at all output speeds. At low output speeds, most of the turbine power of the differential powerplant is used for compressor acceleration. At zero output speed the differential powerplant will accelerate the compressor from 9000 to 13,900 rpm in 2.5 sec, a **reduction in accelerating time** of 65%.

The accelerating time of the differential powerplant increases as the output speed is raised, increasing the portion of turbine power transmitted to the output shaft. At compressor speeds below maximum, the differential powerplant provides more output power than the two-turbine powerplant at the higher output speeds. In the region where the differential gas turbine provides more output power than the two-turbine powerplant, its rate of compressor acceleration is less than that of the two-turbine powerplant.

Fig. 7 plots the steady-state torque-speed characteristics of the two powerplants. The basic difference between their performance is that the two-turbine powerplant provides increasing output torques at constant turbine inlet temperature, as output speed is reduced, while the differential gas turbine provides almost constant output torques at decreasing turbine inlet temperatures as the output speed is reduced.

At the maximum compressor speed, the two-turbine powerplant provides 100% more standstill torque than the differential powerplant. At lower compressor speeds this torque advantage is reduced to 50% at zero output speed and the differential gas turbine will provide larger powers. This comparative improvement in differential turbine performance at low compressor speeds is due to the two-turbine powerplant's progressive decrease in turbine inlet temperature as the compressor speed is reduced.

The reduced turbine inlet temperature of the two-turbine powerplant at reduced compressor speeds is due to the necessity of maintaining the balance of compressor and compressor-turbine power at reduced compressor powers. Although the differential powerplant provides larger output powers at low compressor speeds, these larger powers are provided at lower output speeds than the two-turbine powerplant.

Fig. 8 plots the steady-state fuel consumption of the two powerplants against output power. The two-turbine powerplant requires a constant fuel flow at each compressor speed independent of the output power, while the fuel consumption of the differential powerplant **decreases** rapidly at the reduced output powers. At the maximum compressor speed, the differential powerplant offers fuel savings up to 65%.

Because of the reduction in turbine inlet tempera-

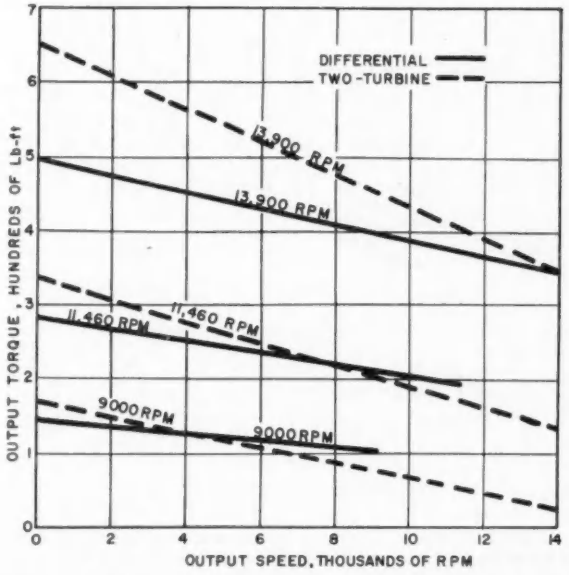


Fig. 6—The torque speed characteristics of two-turbine and basic differential powerplants at a turbine inlet temperature of 1700 F.

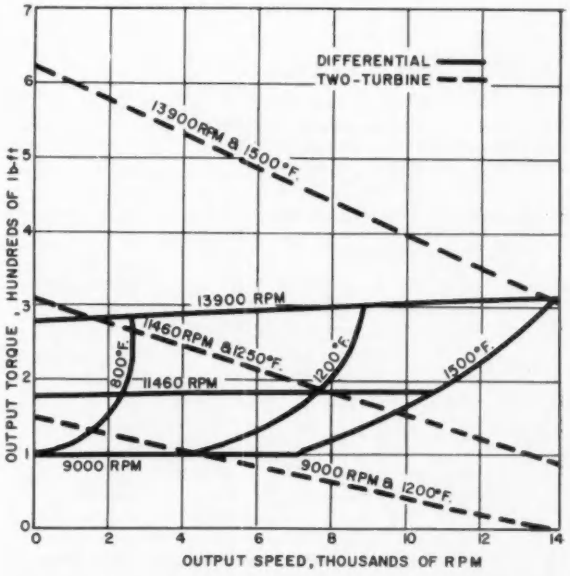


Fig. 7—The torque-speed characteristics of the two-turbine and basic differential powerplants with no compressor acceleration.

ture of the two-turbine powerplant at reduced compressor speeds, the maximum fuel savings of the differential powerplant are reduced to 35% of the fuel flow of the two-turbine powerplant, but the maximum output powers of the differential powerplant are 40% greater.

It is significant that the higher maximum turbine inlet temperatures of the differential powerplant at reduced compressor speeds also enable it to furnish a 10% reduction in specific fuel consumption when operating at these higher maximum output powers.

The Two-Turbine Differential Powerplant

The two-turbine differential powerplant schematically shown in Fig. 9 combines the mechanical features of the two-turbine and differential powerplants. This arrangement was investigated in the hope of achieving a compromise of the outstanding features of each powerplant, that is, the better fuel economy and faster acceleration of the differential powerplant and the better torque-speed characteristics of the two-turbine powerplant.

This powerplant has the turbine divided into two parts with one part mounted on the compressor shaft. The other part of the turbine is mounted on a separate hollow turbine shaft surrounding a compressor shaft extension. A differential serves to connect the compressor and separate turbine shafts to each other and to the output shaft.

In this type of differential powerplant, the part of the turbine mounted on the compressor shaft is designed to provide only part of the power required to drive the compressor. The separate turbine assists in driving the compressor and also provides the output power. Operation is similar to the basic differential gas turbine except that the torque of the compressor shaft is equal to the difference of the torques of the compressor and compressor-turbine and is therefore increased by a reduction in the compressor-turbine torque.

Fig. 10 plots the steady-state torque-speed characteristics of a two-turbine differential powerplant having component performance equal to that of the previous powerplants mentioned. In this case, the compressor-turbine is designed to provide exactly half the power required to drive the compressor at its maximum compressor speed and maximum turbine inlet temperature. These torque-speed char-

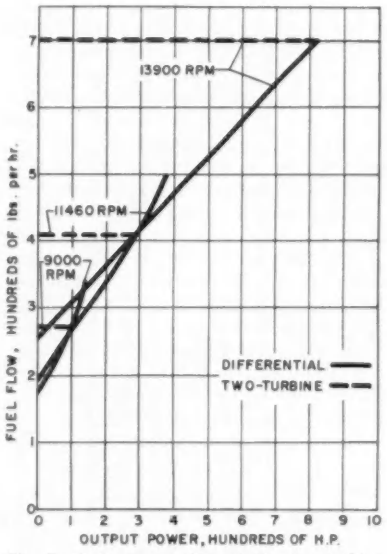


Fig. 8—Fuel consumption of the two-turbine and basic differential powerplants with no compressor acceleration.

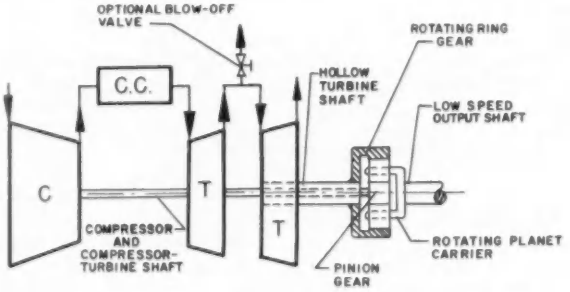


Fig. 9—A schematic of the two-turbine differential gas turbine.

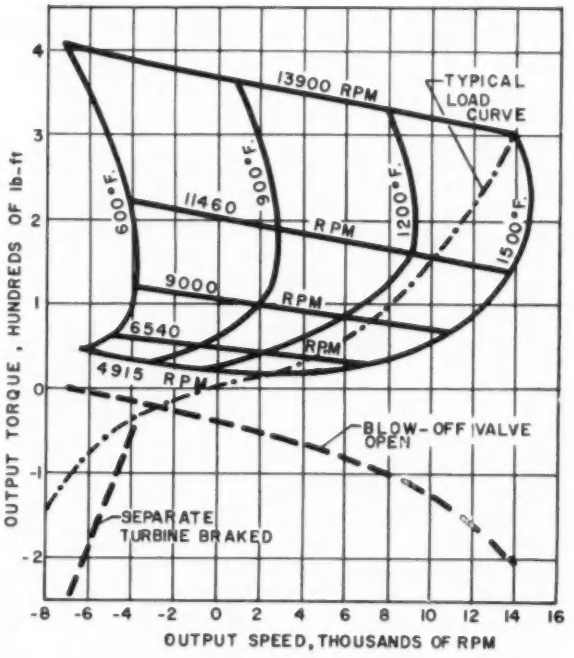


Fig. 10—The torque-speed characteristics of a two-turbine differential gas turbine with no compressor acceleration.

acteristics combine the features of the two-turbine and basic differential powerplants providing increasing output torques with decreasing turbine inlet temperature as the output speed is reduced.

This differential powerplant has extended areas of operation in the high-torque, low-speed and high-speed, low-torque ranges compared to the basic differential gas turbine. Although the maximum steady-state output torque at zero output speed has been increased from 275 to 375 lb-ft, it still falls far short of the 620 lb-ft of the conventional two-turbine powerplant.

The area of operation of the two-turbine differential powerplant includes lower compressor speeds than the conventional two-turbine powerplant. The minimum compressor speed for this powerplant is 4915 rpm compared to 9000 rpm of the two-turbine powerplant. These lower compressor speeds enable the differential powerplant to operate at lower output torques at low output speeds. The minimum output torque of the differential powerplant is 30 lb-ft compared to 150 lb-ft for the conventional two-turbine powerplant.

These torque speed characteristics enable the two-turbine differential powerplant to operate along a propeller or road load curve anywhere between 16 and 100% of the maximum output speed. The conventional two-turbine powerplant can only operate between 50 and 100% of the maximum output speed along such a load curve.

When the two-turbine differential powerplant is operating at 1700 F during compressor acceleration, it provides a maximum output torque at zero output speed of 525 lb-ft compared to the 650 lb-ft of the conventional two-turbine powerplant. The two-turbine differential powerplant also provides reductions in compressor accelerating time of up to 50%.

Fig. 11 plots the steady-state fuel consumption of the two-turbine differential gas turbine. Comparing these data with those of the conventional two-turbine powerplant of Fig. 8 shows that the differential powerplant offers fuel savings up to 50% at the same compressor speeds and output powers. Fuel savings up to 30% are achieved at the same torques and output powers. These data also show the reduction of over 60% in the idling fuel consumption.

Therefore, the two-turbine differential gas turbine provides improved torque-speed characteristics compared to the basic differential powerplant and still maintains large advantages in accelerating times and part-load fuel economy. The conventional two-turbine powerplant provides larger output torques at low output speeds but the differential powerplant can operate over a wider speed range along a typical load line.

Operation in the small area of low torques at high speeds not included in the operating range of the two-turbine differential gas turbine and operation as a brake can be provided by means of an overrunning clutch, or optional blow-off valve shown in Fig. 9.

The opening of the blow-off valve reduces the back pressure of the compressor-turbine, increasing its torque and decreasing the torque required to drive the compressor shaft. If the compressor-turbine back pressure is decreased to atmospheric pressure, the compressor-turbine will provide more torque than is required to drive the compressor and the compressor shaft torque will have been reversed.

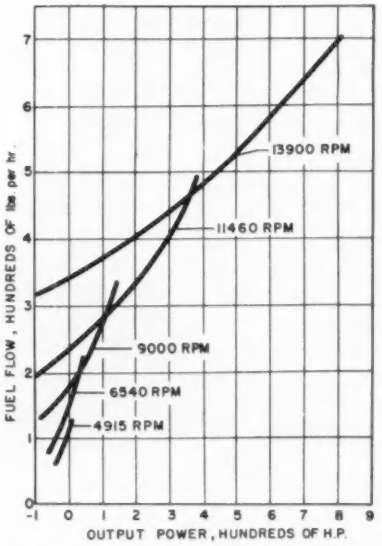


Fig. 11—Fuel consumption of a two-turbine differential gas turbine with no compressor acceleration.

Opening the blow-off valve will also decrease the torque of the separate turbine, and reducing the inlet pressure to atmospheric pressure will cause the separate turbine to act as a brake due to its windage losses. Therefore, opening the blow-off valve reverses the torques of the compressor shaft and turbine shaft and hence reverses the torque on the output shaft, whereby the powerplant acts as a brake. Fig. 10 shows the estimated steady-state braking torques as determined by the windage losses of the separate turbine at maximum compressor speed.

Partial opening of the blow-off valve allows operation at any torque between the maximum braking torques shown and the maximum driving torques achieved with the blow-off valve closed.

With the blow-off valve open, this differential powerplant can provide negative output torques at zero output speed because the separate turbine rotates at about one-third speed when the output shaft is stationary. These negative torques can be used to drive the output shaft in the reverse direction, further reducing the turbine speed. If the separate turbine is then held stationary by a brake, the compressor and compressor-turbine will act as a single-shaft gas turbine and will provide the large negative output torques and negative output speeds shown in Fig. 10.

Reverse powers up to 45% of the maximum power result in this example. This means of providing powers in the reverse direction is particularly suitable for large marine applications and offers many advantages compared to reversible-pitch propellers or reverse gearing.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

Aeronautic Meeting

The

AVIATION faces four challenges as it enters the age of jet-powered transportation:

Challenge No. 1 . . . to the civilian and military: **To determine the best use of our vanishing airspace.**

Challenge No. 2 . . . to the civilian industry: **To determine how the on-order jet and turboprop transports can best and most quickly be integrated into existing airline operations.** (These 161 jet and 170 turboprop airliners will cost more than $1,500,000,000, according to a recent newspaper report; will be delivered in the next few years.)

Challenge No. 3 . . . to the military: **To determine how to keep aircrews alive, healthy, and functioning properly under the steadily increasing speed and altitude operations of modern jets.**

Challenge No. 4 . . . to the producers of turbojets for commercial transports: To make best use of advances in the art of jet engine design. **This will probably mean taking the gains partly in reduced noise and lengthened engine life—instead of entirely in improved power and fuel economy.**

Some problems in these challenges are merely extensions of existing ones. For instance: How will man survive ejection from planes at 100,000-ft altitude and 2000 mph? How does one avoid collisions at such extremely high speeds? Other problems are so new and different that so far we have little information on which to go. For example, how will man adapt to weightlessness?

Using Our Airspace

One question of interest to both civilian and military is: "How can we best utilize our airspace?—which isn't as unlimited as it might seem."

Our present use of airspace is very extravagant, it appears. We are trying to operate high-speed jets with an air traffic control system designed to accommodate the DC-3 and its contemporaries.

In bad weather, for example, only two Boeing Jetliners could fly between New York and Washington at the same time at optimum altitude, with the present system! Reason: Handicapped by the present archaic air traffic arrangement, the CAA, to be on the safe side, has to surround each plane with a cocoon of airspace 10 min long, 10 miles wide, and 1000 ft to ½ mile thick.

What to do about it? Two approaches to the solution were discussed at the meeting:

1. Develop a national aviation facilities system to replace the badly outdated system of air traffic control now in use.

2. Develop equipment for installation in the cockpit that will give the pilot a pictorial display of the traffic in his neighborhood.

In developing a national aviation facilities system, it was stressed that:

1. We should use the most modern techniques of master planning and systems engineering. We might draw on the experience gained in the Air Defense System, the Atomic Energy Program, and the Bell Telephone System.

2. We should make as much use as possible of the present air defense radar system.

3. We will have to classify the airspace in some sensible and equitable way, such as free, monitored, and controlled.

This system could be much simpler if a pictorial display unit becomes available. Such a unit would make it easy for the pilot to avoid collisions, according to its proponents.

Reveals Challenges Posed by

Jet Age

A few of the things that its use would mean are:

1. Inclusion of a warning signal would eliminate the need for continuous watch of the display.
2. The detection of a "collision course" would be immediate. It would be accomplished by comparing the direction of a series of blips.
3. When and where the collision would occur would be found by comparing the length of the series of blips to their distance from the scope center.

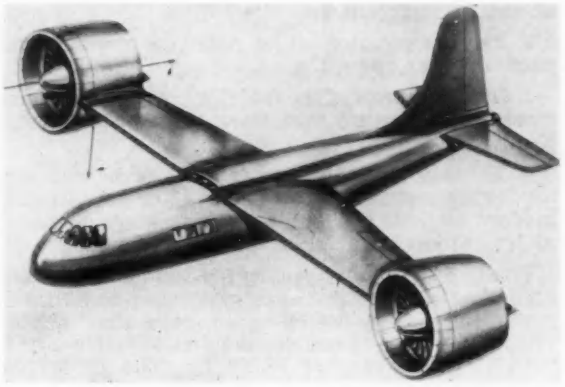
Integrating New Transports into Airline Operations

The jet transport appears to be shaping up into a versatile, flexible machine that is going to integrate easily into present airline operation. Although long-range operation is considered their forte, the newest jets were reported to be flexible enough for short and medium ranges as well, thanks to lower fuel consumption and improved aerodynamics.

For some years to come, however, they will have plenty of competition from the turboprop transport, particularly in the short-medium range. As an indication of future trends, however, at least one turboprop transport is already being designed with small turbojets attached to the wings to increase speed.

Both these uses point up the fact that the jet engine is a mighty versatile animal.

This has not always been so. In its early development stages, it was considered a special-pur-



TWO OF THE TYPES OF VTOL AIRCRAFT under serious consideration for transports are the tilt-wing (left) and the tilt-prop (right). The 1/10-scale model tilt-wing plane has demonstrated successful VTOL (vertical take-off and landing) function in free flight in the Langley wind tunnel under remote control. The tilt-prop transport is a Bell design study in which power is supplied to the ducted propeller installations by a mechanical transmission from turbine engines in the fuselage. Propellers tilt from horizontal to 10 deg ahead of vertical. Opinion at the Meeting favored normal-attitude transports over tail-sitters . . . VTOL craft over STOL (short take-off and landing).

NUCLEAR POWERED TOW PLANE to circle the globe towing commercial airliners was proposed for the sake of stimulating the imaginations of engineers attending the meeting. (It did. Also it stimulated television commentators and newspaper reporters, who gave concept wide circulation.) Idea is that airliner would take off from airport and climb to altitude under own power, then hook on to passing tow plane. Near destination, airliner would drop tow line and descend to airport under own power.

pose vehicle, requiring special operating practices because of the severe range losses associated with nonoptimum cruising altitudes, partial engine operation, and nonstandard temperatures at cruising altitudes.

Recent studies were reported to show, however, that the jet transport, as it has evolved in the Douglas DC-8, retains its long-range speed and cost advantages at both moderate and short ranges. These studies also indicate that:

1. Jets don't have to climb to great altitudes for all operations. When used on the shorter ranges, they do not have to dash up to 40,000 ft but may be scheduled to fly at 20,000–40,000 ft, according to the dictates of wind, weather, and the requirements of airway traffic control.

2. Jets are superior to piston-engine planes during partial engine operation.

3. Some versions of the jet transport are less sensitive to temperature variations than piston-engine planes.

4. Exceedingly long runways will be needed only for the longest-range operations. Runways of most modern airports are long enough to allow operation of jet transports at short and medium range.

The one remaining problem is that more holding fuel is needed to take care of the jet that has to circle over a weathered-in or congested airport. The DC-8 with J-75 engines requires 9000 lb per hr to hold at an altitude of 15,000 ft. The DC-6B requires but 1420 lb per hr for holding at 10,000 ft.

This comparison points up the need for improved traffic control and landing aids to keep these holding times to a minimum for the jets, and avoid diverting them to alternate airports.

Another factor to be considered is that it is always preferable to have the jet hold at high altitude. For the DC-8 an increase of 15% in fuel consumption results from reducing the holding altitude from 30,000 ft to 15,000.

The DC-8 must be designed to carry reserve fuel equal to 5.7% of the maximum take-off weight. The DC-6B needs only 3.6%. In other words, the jet requires 2% more than the DC-6B. Although this doesn't seem like much more, it must be admitted that extended holding requirements will have a more severe effect on jets than on piston-engine planes.

The design of the short-medium range turboprop transport presented a different sort of problem. The job was to develop a 60-passenger, 400-mph turboprop plane having direct operating costs per available seat-mile competitive with fully depreciated medium-range aircraft using piston engines.

The cost requirement was added to give the new transport a reasonable market potential, since the market analysis showed that certain current piston-engine medium-range aircraft would be downgraded into short-medium haul operation when the new aircraft were placed in service.

This problem required a couple of rabbits to be pulled from the hat: a very low initial plane cost and a very efficient powerplant.

It soon became clear that to produce the airplane at a sufficiently low cost, it was necessary to use, where possible, existing products of engineering tooling and manufacturing for a plane long in production.

The powerplant problem was solved by mounting small turbojet engines on the wing tips. At a cruising speed of 375 mph, these small jets provided 2.5 effective hp for each lb of installed weight. As a result, cruising speed was increased by 42 mph with no increase in direct operating cost. With only a small increase in this cost, the cruising speed could be increased by 78 mph.

It appears, moreover, that the reaction of the air

transport industry to this idea has been most favorable. The superior performance and low operating cost was felt to compensate for the disadvantages of maintaining two different types of powerplant.

Man's Adaptation to High Speeds and Altitudes

A problem that the military are already facing, and that eventually civilian operators will also have to face, is man's frailty to extremely high-speed and high-altitude flight. We are coming up against human limitations about which we know little. The one thing that we know for sure is that no matter how high, far, and fast man may fly, he himself will not change. Unless his limitations are understood and taken into account he cannot help but destroy both himself and the fabulous machine he flies. We can only conclude that pilots will require much more mechanical and electronic flight equipment—and that eventually flight will be completely automatic.

The problem naturally divides itself into:

1. Flight at high speed and/or high altitude.

2. Escape from distressed aircraft at high speed and/or high altitude, and survival until rescue is effected.

High-Speed Flight—Velocity, per se, has no physiological significance. It is the effects of change in velocity—or acceleration—its onset, direction, magnitude, and duration—that we must consider. Thus, to say that a flier is subjected to so many *g*'s is insufficient. We must say that the *g*'s come on so fast, apply along such axis, and last so long. Man is tolerant of much higher accelerations if they don't last long and if they apply transversely rather than longitudinally.

For high speeds, we must also remember that man has some built-in limitations, such as: speed

---

Papers presented at the National Aeronautic Meeting in New York, April 9-12, 1956:

J. S. Alford
Jet Engine Department, General Electric Co.
"Turbine Engine Stall from the Design Point of View"

N. L. Barr, Capt., MC, USN, T. A. Hussman, Jr., Lt., USN, J. F. Parker, Jr., Lt., USN
Naval Medical Research Institute
"The Visibility of Airport Runways"

M. C. Beard and F. W. Kolk
American Airlines, Inc.
"Some Safety Aspects of Gas Turbines"

W. A. Benser and H. B. Finger
NACA, Lewis Flight Propulsion Laboratory
"Compressor Stall Problems in Gas Turbine Type Aircraft Engines"

K. S. Coward and E. R. Hinz
Ryan Aeronautical Co.
"An Appraisal of VTOL Aircraft"

Jacques de Vienne
International Civil Aviation Organization
"Avoidance of Aerial Collisions Using Pictorial Traffic Display in the Cockpit"

W. A. Gebhardt and R. Bodemuller
Bendix Products Division, Bendix Aviation Corp.
"Control Approaches to Solution of Compressor Stall"

N. E. Halaby
Laurance S. Rockefeller and Associates
"The American Airspace—A National Asset or Menace"

R. M. Hazen, Dimitrius Gerdan, and R. R. LaMotte
Allison Division, General Motors Corp.
"The Allison Power Package for the Lockheed Electra"

Rudolf Hermann
University of Minnesota and Consultant to Aeronautical Division, Minneapolis-Honeywell Regulator Co.
"Engine Inlet Diffusers for Supersonic Aircraft"

David Huddie
Rolls-Royce, Ltd.
"Development of Rolls-Royce Propeller Turbine Engines"

K. L. Jones, Major, USAF
Wright Powerplant Laboratory, Air Development Center
"A Customer's View on Turbine Engine Stall"

C. G. Martin, Jr.
Fort Worth Division, Convair Division, General Dynamics Corp.
"Supersonic Bomber Propulsion Problems"

Ben F. McLeod
Pan American World Airways, Inc.
"Integrated Flight Systems"

R. L. McManus
General Electric Co.
"Pneumatic Vs. Mechanical Power Extraction for Aircraft Accessories"

G. D. McVicker
Convair Division, General Dynamics Corp.
"Design Considerations of Short-Range Turboprop Transport"

H. G. Moseley, Col., USAF,
Air Research and Development Command
"Human Factors That Cause Aircraft Accidents"

L. A. Ohlinger
Northrop Aircraft, Inc.
"Nuclear Power in the Air of Tomorrow"

A. J. Penn
D. Napier and Son, Ltd.
"The Eland Engine and Its Application to Civil Transport"

J. R. Poppen, Capt., MC, USN (Ret.)
"Man's Adaptation to Increasing Altitudes"

N. D. Sanders and J. C. Laurence
NACA, Lewis Flight Propulsion Laboratory
"Fundamental Investigation of Noise Generation by Turbulent Jets"

E. H. Schroeder
Kollsman Instrument Corp.
"Development of Cabin Pressure Control System for Transport Type Aircraft"

R. S. Shevell
Santa Monica Division, Douglas Aircraft Co., Inc.
"The Versatile Jet Transport"

Abe Silverstein and N. D. Sanders
NACA, Lewis Flight Propulsion Laboratory
"Concepts on Turbojet Engines for Transport Application"

R. M. Stanley and R. J. Heymans
Stanley Aviation Corp.
"Crew Escape in the Jet Age"

J. P. Stapp, Lt. Col., USAF
Chief, Aero Medical Field Laboratory, Holloman Air Development Center
"Human Factors of Supersonic Escape"

R. F. Stoessel and E. W. Fuller
Georgia Division, Lockheed Aircraft Corp.
"Air Freighter Suitability"

J. M. Tyler and R. T. Krieghoff
Pratt and Whitney Aircraft Division, United Aircraft Corp.
"Suppression of Jet Engine Noise During Ground Running"

R. J. Woods
Bell Aircraft Co.
"Convertiplanes and Other VTOL Aircraft"

C. H. Zimmerman
NACA, Langley Aeronautic Laboratory
"Some General Considerations Concerning VTOL Aircraft"

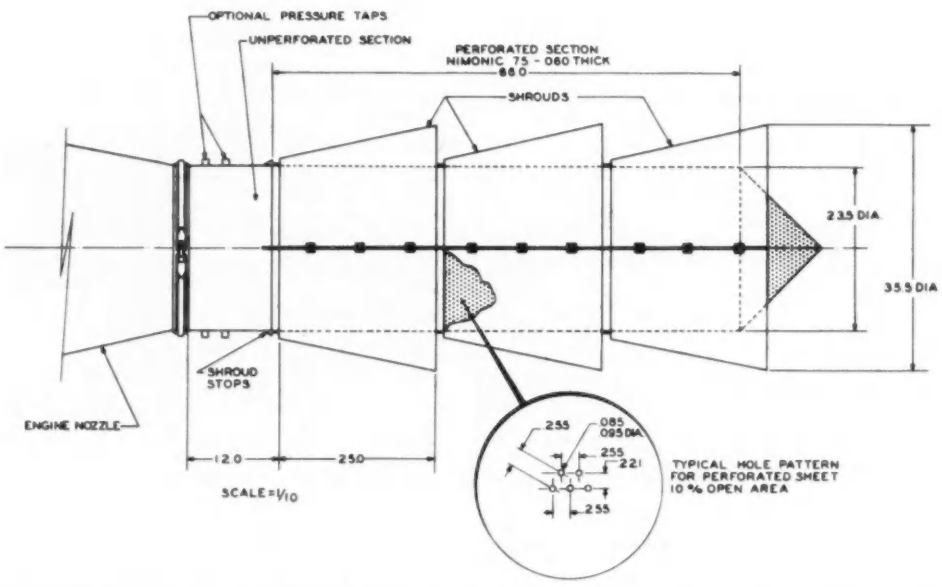
Panel—Fuels and Fuel Systems for Turbine Transports

Co-Chairmen—H. A. Murray
California Texas Oil Co., Ltd.
J. S. Harris
Shell Oil Co.

Secretary—Hugh Harvey
See Page 55 for Secretary's Report

Panel Discussion—Breaking the Time Barrier Between Design and Production

Chairman—Anderson Ashburn
American Machinist
Secretary—R. P. Dominic
Product Engineering



PORTABLE JET NOISE SUPPRESSOR can be brought to airplane to quiet exhaust during ground running. Pratt & Whitney Aircraft has already delivered a noise suppressor of this type to Boeing at Seattle for use with ground running of J-57 turbojets for B-52 airplanes. Suppressor can go directly on installed engine or on ground run-up stand. Boeing uses a supplementary support for the suppressor and removes engine cowling of the B-52. Principle of the device is that small holes give a frequency spectrum that peaks above the audible range. Its designers admit that there is an additional unexplained energy reduction that helps too.

of vision, time of decision, and time of reaction. If two aircraft approach on a collision course, each at 600 knots, and the pilots don't see each other until they are a mile apart, it is humanly impossible for them to avoid a collision.

High-Altitude Flight—In high-altitude flight, man enters a realm that is enormously hostile to his physiological being: reduced barometric pressure, changes in temperature, increased radiation, and no reference point in space for focusing the eyes.

Both the atmospheric pressure and temperature changes can be met by providing adequate artificial environment.

The need for pressurization starts at fairly low altitudes, largely because of the reduction in oxygen partial pressure. Even at 18,000 ft, there is an insidious encroachment on mental functions and neuromuscular coordination, reducing man's efficiency. Above 20,000 ft imminent collapse may be expected.

Increasing the percentage of oxygen in the breathing mixture helps, but, without pressurization, 100% oxygen raises the altitude at which man will collapse to only 43,000 ft.

The temperature problem is complicated by the fact that both hot and cold may be encountered. High altitude means low temperature, but high speed produces the widely discussed "heat barrier."

Insulation, heat dissipation, and cooling are required to preserve an equable climate in the pilot's compartment.

As man escapes from the blanket of the earth's air he will be exposed to concentrations of radiations not found at the surface. Ultraviolet rays, for example, may be strong enough to be of physiological consequence. Filters may be necessary to reduce the radiation intensity.

One of the visual aspects that must be considered is empty field myopia. This condition results when there's no object in space to provide a reference for focusing the eyes. The normal eye can't focus beyond optical infinity, and when it views an empty visual field the average focus is nearer than infinity. In other words, the eye becomes virtually nearsighted. As a result, objects in the field of vision may be so out of focus as to be undetectable. One way out of this dilemma may be to provide a projected image for reference.

Weightlessness—As man explores the outer reaches of space, he is also going to encounter the absence of gravitation or weightlessness. Until we can study this condition under laboratory controls, its physiological effects must remain conjectural.

What do we know about it? Physiological processes that are influenced by gravitational force, such as locomotion, will be materially affected. Objects will not fall. Fluid will not run out of a container into the mouth. Thermal convection will cease, with

stagnation of expired air before the face, and many normal functional procedures will be materially altered. Experience and mechanical means will surely be found to take care of these. More troublesome may be the effect of weightlessness on the functions of special orientation. For instance, will the absence of normal gravitational influences upon the labyrinth in the inner ear result in illusions of the location of other objects in space?

Crew Escape and Survival—The speed and altitude of today's and tomorrow's jets make it very difficult for the pilot to escape.

For the past five years or so, separation from subsonic aircraft has been almost always made with ejection seats. Although they have done a commendable job, even at these speeds they have not been completely satisfactory. For instance, in 1954, there were 118 fatalities out of a total of 518 ejections by Air Force pilots.

It is clear, therefore, that ejection seats will have to be greatly improved as speeds increase, such as by locking the helmet and head to the headrest. This would relieve the spine of 15–16 lb of load, which at 30*g* would be about 450 lb.

Since human responses and coordination become unpredictably erratic under severe stress, there should also be but a single switch accessible to either hand, which would suffice to actuate the whole ejection sequence. Another idea would be to have the parachute attached to the seat so the occupant could ride the seat all the way down.

Another method of escape being investigated is the capsule.

The capsule, although having a weight penalty of about 200 lb, has many advantages. Its trajectory could easily be stabilized, and its mass and streamlining can be such that violent deceleration force need not occur. It would eliminate damage to the occupant from air blast, violent accelerations, loss of oxygen and pressure. It would also provide the occupant with a shelter, a boat, a container in which can be stowed all his survival apparatus.

Efforts in this direction must not go too far. The primary function of an airplane is to fly, so compromises will have to be made between effects on airplane performance and providing for probable escape conditions.

At this date, it is not possible to say which is better—the enclosed or the open escape system. Human limitations are not yet well enough understood. The conditions of escape and the trajectories of seat and capsule in all escape situations must be evaluated.

Whatever system is used, it must be dependable and engineered to human specifications that cover the maximum combination of escape situations. This is the goal of research in the field.

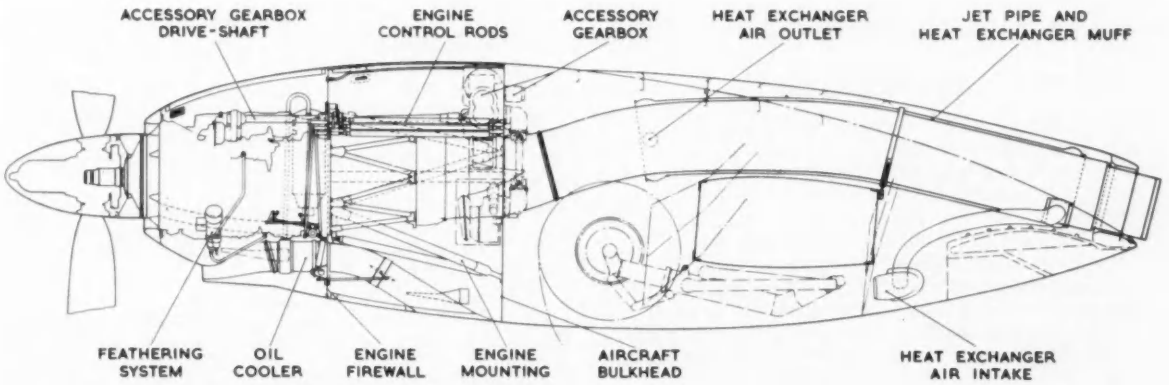
Less Noise, Longer Life for Jets

The art of designing turbojets has reached the state where for commercial uses, we can begin to apply future gains to reducing exhaust noise and to improving engine life. We no longer need to apply all our effort to improving thrust and fuel economy.

This was evident in a number of Aeronautic Meeting sessions where men concerned with powerplants congregated.

It was clear that they expect power and fuel economy to improve. But they feel it can be achieved by improved component efficiencies rather than by higher temperatures and pressure ratios.

The hotter the jet issuing from the engine, the



NAPIER HAS INSTALLED ELAND IN CONVAIR 340 to demonstrate the British turboprop's suitability as a replacement for original piston engines. Eland conversion has 6500 equivalent hp and saves 2000 lb. Cruising speed is 310 mph at a typical mean weight of 47,000 lb for altitudes from 8000 to 22,000 ft. Eland-Convair has fully reversing propellers. Meeting disclosed also that Rolls-Royce Tyne will have reversing propellers and reversing is under development for Dart props.

louder it is likely to be, it was pointed out. Noise energy is proportional to the eighth power of jet velocity—and jet velocity increases with turbine temperature.

NACA found that a projected turbojet (with noise suppressor) having a turbine inlet temperature of 1600 F and a compressor pressure ratio of 8 would be an estimated 15 db quieter than a comparable engine (without suppressor) having a turbine inlet temperature of 1600 F and a pressure ratio of 12. Presumably the greater part of the noise reduction is due to the lower pressure ratio and turbine temperature rather than to the addition of the noise suppressor. (The projected engine has a specific fuel consumption and weight/thrust ratio about equal to those of current jet engines. Diameter is larger and length less.)

Of course, lower temperatures are not the only path being followed in the hope of quieting engines. In another study NACA is investigating fundamentals of noise formation toward the end that researchers can learn enough about it to figure out the optimum noise suppressor. Already NACA noise researchers have shown that the scale of turbulence influences noise. The larger the turbulence, the more noise. Their recommendation is to find a way to increase the size of the region in which the core of the jet mixes with surrounding air without increasing the scale of turbulence.

Bleeding off the boundary layer of the jet isn't the answer to exhaust noise, it was reported. If you bleed off all the boundary layer at one point, you still have turbulence downstream as long as you have mixing.

Answers are being found, however, at least to quieting the noise of engines being tested on the ground. Pratt & Whitney Aircraft announced a new inlet noise suppressor and a revised version of the company's jet exhaust noise suppressor that drastically reduce noise around turbojets undergoing ground testing.

Another ray of hope came from a wag who observed that there must be a limitation to the rule that exhaust noise goes up with the eighth power of jet velocity. Otherwise, he said, we would get more energy out in the form of noise than there is in the fuel.

Longer Engine Life

Lower design engine temperatures and pressure ratios will improve engine life in several ways. For one thing, parts that don't run so hot have longer fatigue life and longer stress-rupture life. NACA estimates that dropping from 1600 F to 1200 F extends fatigue life a thousandfold—and at the same time greatly lengthens stress-rupture life.

(An accidental hot spot, however, can be as bad in an engine designed to be cool-running as in one designing to run hotter. In fact, if the cool engine is more highly loaded, it may be worse, it was pointed out.)

Lower compressor pressure ratios will aid engine life by lessening the dangers of compressor stall. The main cause of compressor failure (outside of foreign object damage) is believed to be fatigue due to rotating stall.

Compressor experts theorized that stall starts in a group of blades where local flow variations or dimensional inaccuracies reduce angle of attack. This local stall condition restricts airflow and thereby increases angle of attack on the next group of blades. When the second group of blades stalls, angle of attack on the blades below decreases and these blades unstall. In this way, stall rotates around the compressor stage.

Rotating stall doesn't necessarily harm compressor performance seriously. But it does impose periodic force variations on the compressor blades. Frequency of these force fluctuations is often close to the natural frequency of the blades. First mode bending is held responsible for blade failures.

Rotating stall and other forms of compressor stall and surge are more of a limitation to high pressure ratio compressors than to low pressure ratio compressors. The high ratio compressors proposed for tomorrow's turbine engines are the reason for a renewed interest in stall problems.

Researchers are diligently seeking a stall parameter that can be measured or synthesized to foretell the onset of stall conditions and actuate controls to alleviate the situation. But no such parameter has come to light yet.

The control manufacturer, meantime, takes the brunt of the stall and surge problem. In terms of the conventional compressor performance map, he has to build a control that puts the acceleration line "in between the stall line and the steady-state line where they touch."

Foreign Object Damage

Discussion at the Meeting indicated that while the Air Force is concerned about the damage stones and other objects do when they are sucked into air inlet ducts and compressor first stages, the airlines are not. Their optimism is based partly on cleaner runways, partly on the Electra's high intake, partly on the ruggedness of the engines ordered for their new transports. Allison movies showed that barrages of 2–3 in. balls of ice fired at inlet of the Model 501 incurred no serious damage. (The Model 501, destined for the Electra, is described on pages 50–54 of this issue.)

Ice formed in the fuel in airplane fuel systems is, however, of serious concern to both airlines men and powerplant engineers, the Meeting showed. It can clog filters and control units, interfering seriously with turbine engine operation. (This problem plus other problems connected with jet fuels and jet fuel systems were discussed in a symposium reported on pages 55–59.)

To protect against icing within engine internal fuel passages, fuel heating is provided in the British Dart turboprop and in certain other British and American engines.

Operators of Dart-equipped Viscounts praised the Dart's ruggedness in session after session. Rolls-Royce is proud that this virtue has been provided at relatively moderate cost. In fact, entire development cost of the Dart is low, when related to the cost of a production engine. Up until the Viscount entered airline service in 1953, development cost had amounted to £4,000,000—which is the cost of only 250–300 production engines. Development is, of course, continuing. Another £2,000,000 had been spent by the end of 1955, and Dart development hasn't ended yet.

NEWS of the SAE
AERONAUTIC
PRODUCTION FORUM

April 9, 1956 Hotel Statler New York, N. Y.

Urgent Need for Reliable, Ready Air Weapons Systems

Assistant-Secretary of Air Force (Materiel) D. C. Sharp Addresses SAE Aeronautic Production Forum Luncheon

NEW YORK, April 9, 1956 (SAE) Concentration on quality is this country's best means of meeting enemy numerical superiority, Dudley C. Sharp, Assistant Secretary of the Air Force for Materiel, told a luncheon meeting of the SAE Aeronautic Production Forum. Our weapons systems must be ready for combat and capable of being supported, operated, and maintained by the personnel and equipment available at the time of delivery and at the point of operation.

Sharp pointed out that one of the biggest problems presently facing the Air Force is maintenance. One third of all Air Force personnel are engaged in maintaining weapon systems, and more than 50% of Air Force maintenance funds now go to industry for assistance in upkeep of equipment. In spite of this, too much equipment is out of commission too often and too long.

Primary cause of this problem is the increasing complexity of aircraft and components that must be operated in increasingly rugged environments. Sharp emphasized the necessity for manufacturers to build reliability, simplicity, and maintainability into their products, as well as high performance. It's the only way to get maximum effectiveness out of our already "technically superior" weapons systems.

Some of the circumstances that lead to excessive trouble in service and costly time-consuming modifications and maintenance can be eliminated, Sharp stated.

To compensate for a manufacturer's lack of experience in producing a specific type of new equipment, we should put more emphasis on trained teams of engineers in certain specialized fields rather than attempt to build up new teams each time new requirements are generated.

Reliability Is Worth Money

In the past too much emphasis has been placed on low initial cost instead of quality and reliability. It is now recognized that the highest quality in a complex item does not generally bear the lowest price tag. Reliability is worth money. A few extra dollars spent in initial cost may be saved many times over by lowered maintenance cost.

Build Reliability In

We must incorporate reliability requirements in development planning along with other performance specifications in terms which can be measured by bench tests in the laboratory and the factory. But reliability can't be achieved solely by specifications and end-inspection. We have to design it into the product, not try to inspect it in.

The Air Force is looking to the manufacturer to take the lead in engineering for better reliability

Continued on page 85

New Materials Needed For Tooling, Fixtures

THERE is a rising need for new materials such as ceramics, plastics, and light metals for tooling and fixtures. One reason for this development is the use of new materials in the aircraft themselves, the panel on *New Trends in Tooling* was told.

Modular fixturing, although not widely used, seems to be a possible solution for job shop tooling.

Disintegration machining may solve problems in cutting which before appeared unsolvable.

Magnesium is being used more and more for fixtures. For some applications it is better than aluminum. It is less expensive, lighter, machines easier, and has better weldability. However, magnesium is subject to cracking on welding. Heat-treating it at 350 F for 1½ hr will normalize it

Four Principles for Production Planning

THE panel *Production Planning for Product Availability* formulated four basic steps in the management process to provide timely product availability:

(1) An objective must be stated and clearly defined.

(2) An operating program must be established. It should be time-phased and reasonable in its requirements and consistent with resources available.

(3) A more or less mechanical report system must keep tabs on the program and be frequent enough to prevent a wide deviation from the objective.

(4) A periodic analysis of progress should be made and positive action taken in the problem areas.

AERONAUTIC PRODUCTION FORUM LEADERS: (Front row, left to right) G. E. Fouch; W. A. Ehrlich; W. K. Perry; G. T. Willey. (Rear row, left to right) J. Y. McClure; M. F. McCammon, forum chairman; J. D. Wethe; R. C. Magner.

Reliability Must Be Designed into the Air Weapons System

EFFORTS to achieve a more reliable product must be started at the beginning of design. Any later start means added expense for retrofit of troublesome components and delays the availability of reliable components, the panel on *Manufacturing and Engineering Responsibility For Reliability* was told. Reliability must be specified in Air Force procurement specifications. Otherwise it is likely that an unreliable product will be bought because of its lower initial cost.

Attempts are being made toward defining reliability and measuring it, but it is a difficult and slow process. We must be able to simulate field conditions better in the laboratory so that equipment can be tested more accurately and the unreliable factors removed before the equipment is sent into service.

So far, investigators of reliability problems have gone to fantastic lengths to isolate trouble. For example, fuel system leaks in a new engine were traced to o-ring deterioration. It was finally discovered that the o-rings had deteriorated because the women factory workers used a protective hand cream that attacked the rubber o-ring.

One of the techniques for helping the manufacturer produce more reliable products is a new method of reporting problems that crop up in service. It's been found that a few detailed qualitative reports are much more helpful than hundreds of superficial complaints.

Too, the Air Force is buying quantities of a component and testing them statistically. In this way, reliability is more closely determined than by merely testing one prototype unit that may be extra good or extra bad.

Control Engineers Design To Prevent Catastrophic Failure

MODERN jet plane control systems are being designed so that in case of failure the pilot will at least be able to bring the plane back, even though his mission is aborted, the panel *Building Reliability Into Aircraft Control Systems* was told. In the past, dual control systems wer used. However, the trend is away from this method because dual systems increase complexity, thus creating more points of possible failure.

In trying to predict if a new control system will work or fail many companies set up the system on jig test stands. Then they drive the system to see how much it can stand. Then, by backing down a little, the designers know they have a safe gain.

Some companies put the controls in flight simulators and test it up to 500 hr. Ideally, the best test is to put the control system in an actual plane and fly it because it is difficult to simulate all actual conditions in the laboratory.

Automation Problems To Be Solved by Productivity Engineers

THE need for close cooperation between manufacturing and product design is particularly vital in automated plants, the panel *Automation and Limited Quantity Production* brought out. A committee of tool engineers and design engineers should be formed to analyse costs, weight, delivery, and manufacturing problems. The findings of these "productivity" engineers will help management to decide the best design and to determine which parts are to be automated.

A system of automatic gaging is imperative in an automated line. These gages tell where tool wear is occurring. There are types that give a signal or stop a machine so that a tool can be replaced or indexed into position. Automatic gaging machines are available that sort the parts into various classifications according to tolerances.

In a case where burrs were causing a die to chip (during the manufacture of some laminated plates for a motor) it was proposed to detect the burrs by optical gaging and to set up an operation to remove the burrs when they occurred.

Although great strides are being made in the research and development of numerically controlled machines, at present, only a few companies are using tape to control machining and then only for small lot production.

Air Weapons System

Continued from page 83

by developing better materials and components. In the early design stages and continually throughout development there must be a meeting of minds between the factory designer and the user to achieve a proper balance between performance and reliability.

Feed Back Information

Since military urgency requires using new equipment as quickly as possible, there is often not enough time for adequate service testing and modification of designs. Manufacturers should insist upon the "feed back" of service information to help them de-bug and refine their products.

Painstaking Engineering

The Air Force is constantly demanding equipment with greater performance in smaller spaces with less weight. This often leads to skimping on designs and sacrificing reliability. So manufacturers must exercise even more careful and painstaking engineering and share the responsibility with the Air Force to develop a reliable and ready air weapons system.

Aero Forum Stresses Availability And Reliability

THE SAE Aeronautic Production Forum held on Monday, April 9, 1956, in conjunction with the SAE National Aeronautic Meeting, at the Hotel Statler, New York, had as its theme "Programming for Product Availability and Reliability." Seven panel sessions discussed problems vital to today's aircraft manufacturing men. Subjects were: *Manufacturing and Engineering Responsibility for Reliability, Techniques of Modern Manufacturing Management, Building Reliability into Aircraft Control Systems, Production Planning for Product Availability, New Trends in Tooling, Quality Control's Role in Product Reliability,* and *Automation and Limited Quantity Production.*

Sponsor of the 1956 Forum was R. P. Lansing, Vice-President, Group Executive, Bendix Aviation Corp. The chairman of the Forum was M. F. McCammon, Assistant General Manager, Eclipse-Pioneer Division, Bendix Aviation Corp.

Recent Survey Shows Security, Not Money Is Prime Interest

A RECENT survey of workers in an industrial plant has found that high salary rates a low fifth in the attributes a worker looks for in a job. Number one on the list is "steady work," followed by "good working conditions," "good boss," and "chance for advancement," in that order. This suprising information was reported at the panel session on *Techniques of Modern Manufacturing Management.*

The panel also emphasized the fact that management is becoming more and more scientific. Top executives are being selected and trained as administrators. Technical skills are considered less important than natural aptitude for leadership.

Aero Production Forum Leaders and Secretaries

Leaders of the Aeronautic Production Forum Panels were:

J. D. Wethe, Marketing Manager, Evendale Operating Dept., General Electric Co.

G. T. Willey, Vice-President, Manufacturing, Glenn L. Martin Co.

R. C. Magner, Chief Controls Engineer, Republic Aviation Corp.

G. E. Fouch, General Manager, Evendale Operating Dept., General Electric Co.

W. K. Perry, Director, Industrial Engineering, Eclipse-Pioneer Division, Bendix Aviation Corp.

J. Y. McClure, Manager, Quality Control, Convair Division, General Dynamics Corp.

W. A. Ehrlich, Chief Draftsman, The Bullard Co.

Secretaries of the Aeronautic Production Forum Panels were:

A. L. Wynn, Jr., Service Manager, Evendale Operating Dept., General Electric Co.

C. G. Kelley, General Supervisor, Factory Liaison, Glenn L. Martin Co.

John Markus, Associate Editor, "Electronics," McGraw-Hill Publishing Co.

Ralph Medros, Manager, Programming and Master Scheduling, Evendale Operating Dept., General Electric Co.

J. R. Cooke, Eclipse-Pioneer Division, Bendix Aviation Corp.

C. M. Ryerson, Reliability Administration, Radio Corp. of America

C. A. Augustine, Chief Draftsman, The Bullard Co.

Production Forum Luncheon speaker, D. C. Sharp, Assistant Secretary of the Air Force (Materiel), speaks with toastmaster R. P. Lansing, vice-president, group executive, Bendix Aviation Corp. Lansing (left) was sponsor of the Aeronautic Production Forum.

At the Aeronautic Meeting . . .

Engineers Discuss Aviation's

NEW YORK's Hotel Statler was the site of SAE's National Aeronautic Meeting on April 9–12. More than 1800 men came from all parts of the country to hear and discuss the various barriers which block aviation's progress. Nine panel discussions and ten technical sessions later, they left for home cognizant of the many problems facing aviation today and better equipped to meet these challenges.

Opening day saw the Aeronautic Production Forum set the meeting into high gear. Seven panel discussions, sponsored by the SAE Production Activity, emphasized the importance of industry programming for product availability and reliability. (See p. 83 for highlights of the Production Forum.)

On Tuesday, General Chairman of the Meeting R. Dixon Speas set three days of technical sessions in motion by welcoming the goodly crowd to the meeting.

Powerplants, accessories, transports, vertical lift aircraft, jet ex-

At the Air Transport Luncheon

ACTION on a new system to prevent the vanishing of America's air space may soon be taken, Stuart G. Tipton, president, Air Transport Association, told the Air Transport Luncheon.

The new system, Tipton indicated, will involve application to the problem of air traffic control of the same sort of electronic devices which have already been applied in other fields. Without such a radically new system, he showed, our country's air power—military and civil—will be handcuffed. Right now, he stressed, America's airspace is a vanishing resource.

Tipton bases his hope for action on the interest now being shown in such a new program by the Aviation Subcommittee of the Senate Committee on Interstate Commerce; on completion of a report on the subject recently completed for the Bureau of the Budget and on President Eisenhower's recent appointment of a Special Assistant for Aviation Facilities Planning, with the assignment of heading up an attack on development of an adequate air traffic control system.

Tipton sees the move to the new system coming in two stages:

1. Immediate steps to install at a greatly accelerated pace devices which are already available and can at once introduce greater capacity and flexibility into the control of air traffic;

2. Simultaneous steps to develop a bold, new, revolutionary future system.

Under existing conditions, he pointed out, our airspace is vanishing fast because the American public is using it to an increasing degree; because the military must exercise a number-one priority; and because it is being used extravagantly.

Stuart G. Tipton (left) tells SAE members of the need for a new air traffic control system. William Littlewood (right) was the toastmaster.

Barriers

haust noise, and fuels were the chief topics. (See p. 76 for highlights of the technical sessions.) Sponsoring the technical sessions were the SAE Air Transport, Aircraft, Aircraft Powerplant, and Production Activities.

As a special feature, Aircraft Propulsion, Air Transport, and Military Luncheons were held at the technical meeting.

Principal speaker at the Aircraft Propulsion Luncheon was Air Commodore F. Rodwell Banks, Engineering Director of The Bristol Aeroplane Co., Ltd., whose subject was "Why Ask Me?" Banks related his views of the coming trends in aircraft propulsion. SAE Past-President A. T. Colwell was toastmaster at the luncheon.

The Air Transport Luncheon featured S. G. Tipton, President of the Air Transport Association of America, as guest speaker. His topic was "Tomorrow's Magic Web." Tipton told of the need for a new system of air control to regulate America's vanishing airspace. SAE Past-President William Littlewood presided as toastmaster.

The first presentation of the Laura Taber Barbour Air Safety Award was made at the Air Transport Luncheon. This award, which will be administered annually by The Flight Safety Foundation, is presented in recognition of outstanding achievement in the field of aviation safety and in honor of the memory of Laura Taber Barbour who died in 1945. Recipients of the first award are: I. Irving Pinkel, Dugald O. Black, G. Merritt Preston, and Gerard J. Pesman, all of the NACA Lewis Flight Propulsion Laboratory in Cleveland, for their development

At the Aircraft Propulsion Luncheon

Air Commodore F. Rodwell Banks presents his views of future trends in aircraft propulsion to SAE members. Interested listener on the right is Toastmaster A. T. Colwell.

"I THINK the open cycle aviation gas turbine will be with us in one form or another for 30 years and more. . . ." That's what Air Commodore F. Rodwell Banks, Engineering Director, The Bristol Aeroplane Co., Ltd., predicted at the Aircraft Propulsion Luncheon on April 10.

Expressing his views on likely future trends in aircraft propulsion, Banks was confident that "hydrocarbon fuels will continue to be used" although he implied that they may be synthetically produced. Acknowledging that nuclear sources of heat energy are coming, he thought its use, for many years, would be limited to special military purposes.

"We can expect the turbojet to be used in military aircraft for speeds up to Mach 2.5 to 3 and, at these speeds, a combination of turbojet and ramjet or rocket seems to be quite feasible," said Banks. "Beyond such velocities, the ramjet and the rocket will obviously be used—and also nuclear energy, when sufficient high grade heat can be safely controlled and released."

In the field of civilian aviation, Banks opined, there will be, indefinitely, a place for both the turbojet and the propeller turbine—certainly up to the practical limits of subsonic flight.

In summing up the present state of gas turbine technique, Banks said "I think we can assume that this has now reached the stage where it will continue to progress steadily by improvements in detail resulting from usage and service experience, and it's unlikely that there will be any large jumps resulting from revolutionary ideas."

SAE Vice-President for Aircraft Powerplant A. L. Pomeroy and his Committee made plans for the next aeronautic meeting. Pomeroy's untimely death three weeks ago temporarily leaves this Activity without a vice-president but plans for the next meeting are already well established.

SAE Vice-President for Aircraft F. O. Hosterman (right) and J. H. Famme, vice-chairman for Meetings of the Aircraft Activity Committee (left) at a Committee breakfast session.

J. T. Dyment (right) and E. J. Foley (left) consider a proposal brought before the SAE Air Transport Activity Comittee. Dyment is SAE vice-president for Air Transport and Foley vice-chairman for Meetings of the Activity Committee.

WRIGHT BROTHERS AWARD was presented to Wendell E. Reed (left) for his paper "A New Approach to Turbojet and Ramjet Engine Control" presented at the SAE Golden Anniversary Aeronautic Meeting, Oct. 14, 1955. This paper was adjudged by the Wright Brothers Medal Board of Award as the best contribution on an aeronautic subject presented at an SAE meeting during 1955. Harold W. Zipp (right), chairman of the 1955 Wright Brothers Award Board, made the presentation.

of a system to suppress crash fires.

Guest speaker at the Military Luncheon was James H. Smith, Jr., Assistant Secretary of the Navy for Air. Speaking on "Democracy's Challenge to Technological Superiority," Smith presented a course of action designed to keep America technologically superior in the jet-atomic race with Russia. Earl D. Johnson, Senior Vice-President, Development and Operations, General Dynamics Corp., was toastmaster.

Session chairmen at the meeting were: N. C. Appold, Colonel, USAF; Anderson Ashburn, *American Machinist;* E. W. Conlon, Turbomotor Division, Curtiss-Wright Corp.; C. M. Christensen, United Air Lines, Inc.; R. W. Rummel, Trans World Airlines, Inc.; F. N. Piasecki, Piasecki Aircraft Corp.; M. W. Arnold, Air Transport Association of America; C. E. Rosendahl, Admiral (Ret.), National Air Transport Coordinating Committee; P. F. Nay, Colonel, USAF; H. A. Murray, California Texas Oil Co., Ltd.; J. S. Harris, Shell Oil Co.; S. R. Ours, Captain, USN; and R. E. Johnson, Wright Aeronautical Division, Curtiss-Wright Corp.

Session secretaries were: E. C. Simpson, Power Plant Laboratory, WADC; R. P. Dominic, *Product Engineering;* N. C. Witbeck, Turbomotor Division, Curtiss-Wright Corp.; John Tillman, United Air Lines, Inc.; W. H. Spannuth, Trans World Airlines, Inc.; F. E. Mamrol, Piasecki Aircraft Corp.; W. A. Jensen, Air Transport Association of America; J. F. Ramsberger, John Moynahan and Associates; R. C. Harrison, Major, USAF; Hugh Harvey, Shell Oil Co.; P. D. Dugan, Bureau of Aeronautics; and J. D. Redding, Westinghouse Electric Corp.

The 43 exhibitors at the Aircraft Engineering Display who brought news on their latest products were:

Cleveland Pneumatic Tool Co. . . . Al-Fin Division, Fairchild Engine & Airplane Corp. . . . Jack & Heintz, Inc. . . . Aluminum Co. of America . . . Stratos Division, Fairchild Engine & Airplane Corp. . . . Revere Corp. of America . . . Curtiss-Wright Corp. . . . Hoover Electric Co. . . . New York Air Brake Co. . . . Linde Air Products Co.

Foote Brothers Gear & Machine Corp. . . . Electrofilm, Inc. . . . Fairchild Engine Division, Fair-

R. Dixon Speas, general chairman of the Meeting, extends a welcome to the 1850 engineers who attended the National Aeronautic Meeting.

H. R. Harris, chairman of the Aircraft Engineering Display, sits in on an SAE Air Transport Activity Committee Meeting.

R. M. Cherryholmes, SAE Metropolitan Section chairman, enters the Grand Ballroom of the Hotel Statler to look at the Aircraft Engineering Display.

At the Sky-Ball Dinner-Dance Mr. and Mrs. J. T. Dyment celebrate their twenty-fifth wedding anniversary at the Sky-Ball Dinner-Dance. Dyment is 1956 SAE vice-president for Air Transport.

More than 400 people attended the dance and enjoyed the music of "Sky" Peterson and his Meteorites. As a special added attraction, airline hostesses from National and International Airlines distributed corsages to the ladies and boutonnieres to the men.

child Engine & Airplane Corp. . . . Westinghouse Electric Corp. . . . Lebanon Steel Foundry . . . Nylok Corp. . . . Thompson Products, Inc. . . . Rosan, Inc. . . . Houdaille Industries, Inc., Buffalo Hydraulics Division—Aircraft.

Saginaw Steering Gear Division, GMC . . . Elastic Stop Nut Corp. of America . . . General Controls Co. . . . Garrett Corp. . . . Pratt & Whitney Co., Inc. . . . Aeronautical Service Engineering . . . Fasteners, Inc. . . . Kaynar Co. . . . Titeflex, Inc. . . . Vickers, Inc. . . . Lord Mfg. Co. . . . United States Steel Corp.

General Electric Co. . . . Merrill Engineering Laboratories . . . Mycalex Corp. of America . . . Metal Finishing Service . . . W. H. Nichols Co. . . . Sperry Gyroscope Co. . . . Mechanics Universal Joint Division, Borg-Warner Corp. . . . Cleveland Graphite Bronze Co. . . . Pesco Products Division, Borg-Warner Corp. . . . Potter Aeronautical Co. . . . Glenn L. Martin Co.

Earl D. Johnson (left) welcomes James H. Smith Jr. (right), Assistant Secretary of the Navy for Air, to the SAE National Aeronautic Meeting. Johnson was toastmaster, Smith was principal speaker.

At the Military Luncheon

THE Russians are formidably challenging America's technological superiority, James H. Smith Jr., Assistant Secretary of the Navy for Air, said at the Military Luncheon.

The Russians are turning out engineers and scientists at more than twice our rate, he said. If the current trend continues we will soon forfeit our lead in scientific and technical skills.

To win this jet-atomic race, Smith suggested:

1. Building an educational system which can identify and motivate gifted students; and convince the students of the worth of scientific training, both to the individual and to the country.

2. Develop the type of air-minded citizen that is required to work in civil and military aviation so we can legislate intelligently a constantly changing National Air Policy designed to accommodate the velocities and altitudes at our disposal.

3. Realize that the Nautilus has opened a door both to a great advance in nuclear propulsion and to a medium of transportation as yet unexploited.

4. Accept certain calculated risks by the government-industry team in the constant battle to compress the time factor between the birth of an idea and the delivery in quantity of a combat weapon.

5. Support of basic research and development programs by all of the technical and industrial capacity in the United States on a much larger scale than in the past.

6. Meet industry production schedules.

7. Provide for reasonable and timely safeguard of military secrets without diminishing the free exchange of scientific information.

Smith concluded: "The government-industry team will work closely together and so combine our moral, political, economic, and scientific resources as to insure the maintenance of our technological superiority."

Seventh Annual Earthmoving Industry Conference

"Beaten Paths Are For Beaten Men"

Reported by **Harlan Banister,** Caterpillar Tractor Co.

WITH the above theme, the 1956 Earthmoving Industry Conference opened in Peoria, Ill., on April 3 and continued through April 4. A record attendance of 1500 engineers, contractors, manufacturers, designers, administrators, and salesmen attended this Conference, which is operated annually by the SAE Central Illinois Section.

In the keynote address opening this meeting, Dr. Harold Vagtborg, president of the Southwest Research Institute used as his theme "Beaten Paths Are for Beaten Men" and in his text he made three major points:

1. Nothing is so perishable as an established product.

2. Whatever you are doing, you can do it better.

3. The greatest handicap to engineering progress is its traditions. These three points can serve as a basis for an engineering philosophy, particularly for young men in the profession.

The question "Why?" is one of any engineers most potent tools. In developing his topic, Dr. Vagtborg indicated four "bench marks" of the present engineering world:

1. There are no new land areas to develop.

2. The population of the world is increasing by ½ billion every 10 years.

3. The world is growing smaller, so it is easier to get around.

4. Natural resources are fixed—we can add nothing.

These all point in one direction. We must produce more and more from less and less, faster and faster. "How?" Science and technology are the only multipliers of these fixed resources with today's science, becoming tomorrow's engineering.

Engineering and engineers must be more inquisitive than ever and not be afraid to explore new paths or go over old ones from a new direction.

More and more money is being spent on research, with $4 billion spent in this realm last year. A total of $40 billion has been spent in the United States from 1776 to 1956, but the halfway point for this expenditure is 1948!

Still money only provides the manpower and tools. Men must provide the skills and inquisitive minds,—minds which will ask "Why?" All new paths are for exploring, with "engineering traditions being the greatest handi-

AT THE CONFERENCE: Members and guests get together before the opening session. (Left to right) R. J. Furstoss, Conference General Chairman; J. A. C. Warner, SAE General Manager and Executive Secretary; (seated) Dr. C. G. A. Rosen, Caterpillar Tractor Co., and 1955 SAE president; Dr. Harold Vagtborg, President Southwest Research Institute, who delivered the keynote address.

cap or obstacle in this exploration and tending to lead down the beaten paths."

Following Dr. Vagtborg's keynote address, C. W. Richards of LeTourneau-Westinghouse acted as technical chairman for the Tuesday morning sessions. Highlights of the two papers of this session are:

How To Design For Easy Maintenance

Designing for maintenance implies the conception of how a machine is to be designed and the parts arranged so as to be practical to install and remove in the space available. The idea or design must be workable, practical to manufacture, and feasible to maintain with a minimum of effort and the average shop equipment.

Much has been done in designing for maintenance, but much is still to be done. The field of construction machinery is going to be a field of opportunity for a long time to come—in construction and maintenance of highways, railroads, airports, and bridges. In some cases this equipment will be concentrated in a relatively small area, in other cases scattered over a wide area. Regular daily service periods should be set up for this equipment and the designer should make every effort to keep the service points as few as possible.

Manufacturers are constantly improving equipment. It is more necessary than ever for all concerned to have a thorough knowledge of equipment. Education of operators in the performance of recommended service is necessary. All types of class instructions and manuals should be used. Because of acute shortage of trained mechanics, the customer is willing to pay more for machinery which can be serviced by average personnel. Lubrication outlets should be easy to locate and self-cleaning. Parts should be 100% interchangeable. Clearances should be large for all wrenches. Accessibility is one of the service or maintenance man's most important factors.—*Designing for Maintenance—Crawler Tractors*, **H. M. Bidwell**, Assistant Chief Engineer, Allis-Chalmers Mfg. Co.

How To Design For Serviceability

A tractor to run for a year—without fueling—without servicing!

This is the challenging concept of earthmoving equipment expounded in the paper "Designing for Serviceability," by F. A. Grooss of Caterpillar Tractor Co.

The paper deals principally with serviceability, leaving once-a-year fueling problems to the atomic scientists who are approximately 2/3 of the way to this goal with the eight months unrefueled operation of the submarine "Nautilus."

For the service problem portion of this proposal the designer has two main roads open: (1) Component assembly—where each portion of the vehicle is a unit, engine . . . transmission . . . torque converter . . . final drive. This requires the attendant lines, lubes, and linkages. (2) Unit construction—where the parts of a vehicle are designed as a unit enclosed in rigid box type structure.

The first gives better serviceability in that it is easy to replace components. The second gives long periods of operation at a sacrifice of serviceability.

Both have features of merit, and examples of both types and combinations of both are in operation. With an ultimate goal of yearly servicing of equipment most designs lean toward the unit, or second, type of construction.

There are several fundamentals to be kept in mind when designing for long service periods. These are (1) establish realistic, common service periods for all equipment. (2) Reduce the number of service points. (3) Increase means of keeping dirt out of filler and gage openings. (4) Use common sizes and types of filters. (5) Make parts easier to assemble and dis-assemble correctly whenever service is necessary.—*Designing For Serviceability*, **F. A. Grooss**,

Assistant to Vice President, Caterpillar Tractor Co.

How To Transmit Power

The Tuesday afternoon technical session was a symposium concerned with the subject of getting the engine output of a vehicle transmitted and transformed into a state capable of enabling the vehicle to perform work. D. W. Erskine of Allis-Chalmers Mfg. Co. acting as technical chairman, presented the speakers and led the discussion.

The paper by John Borland of Rockwell Spring and Axle Co. entitled "Conventional Drive Lines as Applied to Earthmoving Machinery" gave the overall picture of drive lines and the integration of their various components. Several new transmissions of unique design were discussed which proved to be of special interest.

Pointing out that it is not satisfactory to build a single type of transmission and then attempt to modify it to fit various applications, H. C. Kirtland of General Motors Corp. developed the case for the Torqmatic drive. The increased usage of these arrangements in recent years has contributed to greater machine productivity, extended power train life, and lower maintenance cost. Proper matching of the torque converter with the engine and the development of clutches capable of handling the torque in the planetary transmissions were mentioned as occupying positions of importance equal to that of the hydraulic control system design.

J. H. Hyler of LeTourneau-Westinghouse Co. stressed the need for simple and easy-to-operate transmissions in his paper entitled "Tournamatic Drives for Tractors." The new Tournamatic transmission is a constant mesh multiple countershaft unit utilizing air clutches and a single stage torque converter. After pointing out the operational advantages resulting from power shifting over a wide speed range, Hyler emphasized that power shift transmissions are not able to match the low initial cost, simplicity, or maximum efficiency of sliding gear transmissions. The selection of a power shift or sliding gear transmission must be made on the basis of the job application.

An interesting explanation of planetary power steering as applied to crawler tractors was presented by P. J. Sperry of International Harvester Co. The present practices and future possibilities of differential steering were developed in detail.

The highlight of Tuesday's activities was the annual banquet. The banquet speaker was Tom Collins, Publicity Director of the City National Bank and Trust Co. of Kansas City, Mo. Collins entertained the audience of 750 with his distinctive and humorous style of speaking.

The technical chairman of the Wednesday morning session was O. A. Bossart of Young Radiator Co. The first paper from this session was "Cooling Problems Due to Mounted Equipment," presented by E. H. Panthofer, vice-president of Perfex Corp., with prepared discussions by K. A. Beier, Schwitzer Corp., and E. J. Bentz, Caterpillar Tractor Co. The second paper was "The Use of Heavy Equipment in Logging," presented by Gordon A. MacGregor, president of MacGregor Triangle Co., with prepared discussions by William Kind, LeTourneau-Westinghouse Co., and R. D. Salter, Caterpillar Tractor Co. Highlights of the papers are:

Solving Cooling Problems

Certain conditions are assumed or expected when a cooling system is designed. We, of course, never have any problems until the unexpected begins to happen. Similarly, cooling problems are only encountered when items deviate from the theoretical anticipated condition. Any mounted equipment or guards which affect the air or coolant flow affect the cooling to some degree. These are not always obvious, especially on the coolant side. Such things as the water pump cavitation, air or combustion gases in the coolant, and restriction to coolant flow must be considered.

Much can be done to help by providing proper baffling and shrouding of the core and fan and some thought being given to placement and spacing of the mounted equipment with respect to the core and fan.—*Cooling Problems Due to Mounted Equipment,* **E. H. Panthofer,** vice-president, Perfex Corp.

Heavy Logging Equipment

For the most part, loggers design and construct their own haul roads. The logger has designed and built his road with sufficient base and adequate structures to withstand 40,000 lb axle loading, 200,000 lb gross weight on five-axle truck and trailer units, overall axle spacing of 40 ft. The equipment the logger uses in his road construction is about the same as that used by a general contractor engaged in highway construction and specializing in grading. The logger uses a greater proportion of large tractors equipped with angle dozers, than does the contractor engaged in public highway construction who needs more power shovels and hauling units. All safety conscious loggers equip the cabs of their road building tractors with heavily constructed cab guards, usually of their own design. Heavy duty radiator guards, engine, belly, and roller guards are a necessity on tractors used in the woods.

Crawler tractors, ranging from 63,000 lb with 230 drawbar hp to 8,500 lb with 35 drawbar hp, are used in skidding logs. It is estimated that about 12,000 crawler tractors are engaged in logging in the 12 western states.

Rubber tired tractors are coming into use on long swings (skids) and are replacing crawler tractors

GUEST SPEAKER: Tom Collins, publicity director of the City National Bank and Trust Co. of Kansas City, Mo., entertained 700 members and guests with a humorous talk "The Ape and the Shotgun" at the banquet.

Earthmoving Conference Committee

These committee chairmen, with the help of approximately 75 members of the Central Illinois Section, carried out the various details of the Seventh Annual Earthmoving Industry Conference.

General Chairman
R. J. Furstoss

Secretary
M. W. Clark

Treasurer
G. W. Eger

Program Chairman
T. M. Fahnestock

Housing Chairman
F. H. Norris

Publicity Chairman
I. R. Lamport

Finance Chairman
R. K. Polak

Arrangements Chairman
J. S. Smith

Assisting Harlan Banister, Field Editor, in this report were Chalmer Cloyd, N. K. Lammers, W. J. Lux, C. S. Morris, and Robert Pocklington, all from Caterpillar Tractor Co.

and logging arches in a few instances. However, the crawler tractor for the most part is still required to bunch the logs to a skid road for the rubber tired tractors, if the ground is very steep or rough.

The term "jammer" as used in western pine language is a log-loading or skidding machine which is usually a converted track-mounted shovel or truck-mounted crane. At the present time there are about 2000 jammers used in the western states alone for skidding and loading logs, representing an investment of approximately $50 million. It is predicted that loggers will use jammers to a greater extent for skidding.

Many off-highway trucks used in the west are engineered to haul loads of 100 ton, at a speed of 30 mph. Strapping truck loads of logs into bundles of 5000–7000 board ft, and transferring bundles from specialized, timber hauling trucks to over-the-road trucks is one of the latest methods of truck-logging in mountainous Idaho.—*The Use of Heavy Equipment in Logging,* **G. A. MacGregor,** president, MacGregor Triangle Co.

Rebuilding Roads

Technical Chairman of the Wednesday afternoon session Prof. Ellis Danner aptly said, "Our conference has been like an excellent banquet, the entree was consumed with gusto, the main course was a feast without compare, and now, to enjoy a fine havana with a snifter of old brandy." Although figurative, the concluding paper and closing address produced just such mental enjoyment.

Sedgwick County, Kan., Engineer R. S. Kirk, spoke of repairing and maintaining the secondary system of roads in his home county. These section line roads, or "land use" roads as they came to be called, were the boon and blessing to the pioneer, but, with the advent of the horseless carriage, they became a spectre of dust. The problem: rebuild, repair, and maintain these secondary roads. The question remained as to the means and method of solving the problem. At first the farmer maintained his section of road with the "split-log" drag. That mode of solution soon became inadequate, and the hard wheel tractor began breaking down traffic hog backs. These tractors too were soon lost in the dust of ever increasing farm to market traffic. Next, road planers, drawn scrapers, and graders entered the contest of keeping roads up with the demand of traffic. Success in the endeavor has been slow in coming, and the battle is far from won. However, with the advent of present day high speed auto patrol units, bottom dump wagons, scrapers, and paving equipment used in the scheme of synchronized planning by state-county road commissions, a great improvement has been and is being made.

The original "chewing gum" roads have given way to the black top. Through the use of these new earthmoving machines the road base is constructed; scarifiers, spreaders, and rollers then take over and lay down and finish off these asphalt roads. Road shoulders and off-the-road work have been taken from the man and given to the engine driven post hole digger and chain saw. This then is the new road of Kansas and the nation in general.

To finance these secondary roads the "poll tax" has gone the way of the log drag. Now federal funds supplement state and county road appropriations to get the work done. Allocations for these farm to market roads are based at $3000 per mile. Major road rebuilding or arterial highway construction is out of the scope of the county commission, equipment-wise, and must be done by construction contractors. However, Sedgwick County has had no difficulty in keeping 220 employees and 250 pieces of equipment busy in reworking and maintaining 530 miles of secondary roads; and, through adequate planning a financial reserve has been created to extend and maintain the system of secondary roads.

From The Ground Up

G. A. Bowie, Firestone Tire & Rubber Co., Public Relations Department provided the figurative heady brandy to climax the banquet.

For the earthmoving engineer great advances are being made by the rubber industry. They have been made and are apparent on the market today. The tubeless tire is an excellent example. And, for the designer of today's machinery the twin problems of heat dissipation and tread surfaces to do a specific job have not been forgotten. This challenge to create a tire to meet tomorrow's specifications is being met and dealt with. Thereby, from the ground up the tire industry will do its level best to match the creative genius of the earthmoving engineer of today and tomorrow.

And so ended the 1956 Earthmoving Industry Conference, and already plans are being made for the 1957 Conference to be held in Peoria, Ill., on March 26 and 27, 1957. The Central Illinois Section of SAE gives assurance it is looking forward to being host to its many friends who have each year made this Conference more successful.

TUESDAY MORNING SPEAKERS: (Left to right) H. M. Bidwell, Allis-Chalmers Mfg. Co.; F. A. Grooss, Caterpillar Tractor Co.; and C. W. Richards, LeTourneau-Westinghouse Co., Technical Session Chairman.

WEDNESDAY MORNING SPEAKERS: (Left to right) E. H. Panthofer, Perfex Corp.; O. A. Bossart, Young Radiator Co., Technical Session Chairman; G. A. MacGregor, MacGregor Triangle Construction Co.

WEDNESDAY AFTERNOON SPEAKERS: (Left to right) G. A. Bowie, Firestone Tire and Rubber Co.; Professor Ellis Danner, University of Illinois; R. S. Kirk, Segwick County Engineer, Kan.

TUESDAY AFTERNOON SPEAKERS: (Left to right) P. J. Sperry, International Harvester Co.; J. H. Hyler, LeTourneau-Westinghouse Co.; J. Borland, Wisconsin Axle Division, Rockwell Spring & Axle Co.; H. C. Kirtland, Allison Division, GMC; and D. W. Erskine, Allis-Chalmers Mfg. Co., Technical Session Chairman.

About SAE

Kent | Voddon | Copitzky | Vanderbilt

Ochs | McGinn | Doyle | Neudeck

Boll | Coe | Whitesides | Reichman

P. J. KENT, executive engineer, Electrical Section, Engineering Division, Chrysler Corp., was treated to a retirement dinner, May 1, 1956, by a group of his friends. He had been with Chrysler Corp. since 1923.

Kent has been one of SAE's most active members since he joined in 1920. He served as chairman of the Detroit Section in 1930–1931. He was an active member of the Lighting Committee. He served on the SAE Council in 1950–1951. From 1950–1952 he was chairman of the Electrical Equipment Committee. He was also chairman of the Vehicle Radio Interference Committee.

Among his special activities was service as technical observer for SAE at Army Ground Forces Operation "Tack Force Frigid," Fairbanks, Alaska, in 1947. Another favorite pastime was representing SAE and other technical organizations on international delegations, such as the Delegation to the International Commission of Illumination at Turin, Italy.

In April to May, 1954, Kent was a member of the Detroit Fifth International Trade Tour to Europe and the Middle East, visiting Ireland, Italy, Greece, Israeli, Turkey, Austria, Switzerland, and France.

BERTRAM VODDON, service manager for Hall-Scott Motors Co. in Berkeley, Calif., has been named manager of the new Hall-Scott Pennsylvania branch, located at Upper Darby. This branch will handle Hall-Scott and ACF buses, as well as engine dealers and users in eastern states.

JOHN A. COPITZKY is now in Honduras, Central America as general superintendent of shops (Honduras Project) for Porter, Urquhart, McCreary, & O'Brien, Newark, N. J.

Copitzky had been associate equipment engineer with California Division of Highways, Sacramento.

VERN C. VANDERBILT, JR., former Purdue University professor, has joined Perfect Circle Corp. as chief research engineer. Announcement of his appointment was made by **ARTHUR M. BRENNEKE**, Perfect Circle's chief engineer.

Vanderbilt has been a research consultant to Perfect Circle for the last nine months. He has also done research for du Pont, General Electric, and Eastman Kodak.

In his new post, he will direct road testing, the dynamometer laboratory, and general research.

CLARENCE I. OCHS has retired as chairman of the board of Eaton Manufacturing Co. He has, however, been elected chairman of the executive committee and will continue as a director of the company.

HOWARD J. McGINN succeeds him as chairman of the board. He succeeded Ochs as president in March, 1951 and will continue in this office, serving as both chairman and president.

I. G. BOHRMAN, president of the Perfex Corp., announces the formation of a new division of the company to primarily develop, sell, and manufacture specialized heat transfer products and other assemblies.

F. W. DOYLE, who has served Perfex for the past 10 years in the capacity of sales engineer and assistant sales manager, has been appointed sales manager of the new division.

GENE T. NEUDECK, formerly with the National Water Lift Co., will assume Doyle's duties as assistant sales manager of the Industrial Radiator Division.

C. R. BOLL has been elected to the Board of Directors of Cummins Engine Co., Inc. He is the company's vice-president—sales.

P. K. COE, manager of Goodyear Tire & Rubber Co.'s Detroit office, has been promoted to a vice-president of the Goodyear sales company. He will continue his duties in the Detroit office.

WILLIAM F. WHITESIDES has been appointed engineering manager for Flight Refueling, Inc.

He was formerly in charge of various aircraft fuel systems at Douglas Aircraft Co.'s El Segundo plant.

ALEXANDER REICHMAN has been named special assistant to the president of Mack Trucks, Inc. He was assistant chief truck engineer for Studebaker-Packard Corp., where he had served for 22 years.

Members

Lighton

Schwartzwalder

Williams

Rummel

Berry, J. G.

Ford

Miller

Sennstrom

Flinn

Johnson

Greene

Moe

J. G. BERRY has been appointed director of field engineering and service for the tire division of United States Rubber Co. He was formerly automotive engineering manager. He started with U. S. Rubber in 1937.

W. I. FORD has been appointed to succeed Berry as automotive engineering manager. He will be responsible for field engineering activities on all original equipment supplied by the tire division. He was formerly chief engineer of field engineering and service.

SIDNEY E. MILLER is now vice-president and general manager of American Bosch Division, American Bosch Arma Corp. He has been serving as vice-president—engineering.

HAROLD R. SENNSTROM succeeds Miller as vice-president—engineering. He has been vice-president—product development.

WALTER L. FLINN has been named head of the new Washington aircraft office of Vickers, Inc. He moves from the company's home office in Detroit.

Since joining Vickers in 1948, Flinn has been responsible for foreign and domestic airlines liaison, foreign airframe accounts, aircraft products promotional activities, and some special assignments.

Joining Flinn in the Washington office will be **JORDAN E. JOHNSON**, who also moves from the home office in Detroit. He will continue to provide application engineering assistance to users of aircraft oil-hydraulic systems in the Mid-Atlantic area, including Philadelphia and Baltimore, a service he has performed since 1953.

WAYNE EWING, president of Arrowsmith Tool and Die Co., Inc., has been elected third vice-president of the American Society of Tool Engineers.

DR. L. E. LIGHTON retired May 31, 1956 as a vice-president of Electric Storage Battery Co. He had been with the company for more than 35 years.

Lighton has served as vice-president for 10 years, and has devoted himself for the past year to the establishment of the corporate Research Department of the company.

His original service to the company was in the field and headquarters sales organization.

Announcement of his retirement was made by **C. F. NORBERG**, president of the company.

Dr. Lighton plans to enjoy some of the hobbies that he has been sacrificing for his work. Included in the long list of plans are fishing, traveling, photography, history, and gardening.

KARL SCHWARTZWALDER, director of research for AC Spark Plug Division, GMC, has been installed as president of the American Ceramic Society. He has been a member of the Society since 1931. Retiring president **ROBERT TWELLS** conducted the installation at the Society's 58th Annual Meeting in New York.

SELDEN T. WILLIAMS, general manager of A. Schrader's Son Division, Scovill Mfg. Co., has been named a director of Scovill. He has been a vice-president of Scovill.

Williams is also president and treasurer of Schrader-Scovill Co., Prop., Ltd. of Australia.

ROBERT W. RUMMEL has been elected vice-president, engineering, of Trans World Airlines. He had been chief engineer for TWA.

The new vice-president joined TWA in 1943 and has since served in various engineering capacities.

In 1954 he was SAE vice-president representing Air Transport Activity. He has served on a number of Air Transport Association committees and the Air Coordination Committee.

DONALD M. BALDWIN, formerly director, Traffic Operations Division, National Safety Council, is now executive secretary for the Institute of Traffic Engineers.

Baldwin is a member of the SAE Committee on Seat Belts.

JOSEPH R. GREENE, formerly experimental production superintendent, Solar Aircraft Co.'s production division, has been reassigned to head a newly organized Solite Production Department.

CLARENCE O. MOE, gas turbine project design engineer assumes Greene's duties as experimental production superintendent.

Greene joined Solar in 1932. Moe has been with the company since 1936.

White Motor Promotes Five

Black

Bauman

Tobin

Adams

Roesch

ROBERT F. BLACK is now chairman of the board and chief executive officer of White Motor Co.

J. N. BAUMAN has succeeded Black as president. Bauman has been executive vice-president for the past year.

Three other SAE members received promotions.

P. E. TOBIN, who has been general sales manager, now is vice-president, sales.

J. E. ADAMS is now vice-president, manufacturing. He has been serving as general manager in charge of manufacturing.

K. A. ROESCH, general manager of the Autocar Division, has become vice-president in charge of that division.

ARTHUR W. JUDGE's new edition of his well-known text, "Modern Petrol Engines," has recently been published. The book covers automobiles, aircraft, marine, and stationary high-speed gasoline engines. Although it deals largely with British practice, it also includes references to United States research and practice. It contains recent information on detonation research, combustion-chamber design, and alternate fuels for gasoline engines, including the various fuels for high-output and racing engines. Since the volume was written originally for engineers, designers, draftsmen, and students, as an introduction to the subject, it contains a minimum of mathematics and academic treatment. It is published by Chapman & Hall, London, 1955.

JOHN L. ERNST has been named a section head in the technical service unit of the Esso Research and Engineering Co. In his new position he is responsible for activities in the polymers field. He had been a group head.

C. V. CROCKETT, chief engineer, GMC Truck & Coach Division, has announced promotions of two SAE members in the truck engineering staff.

M. T. HAYES, former assistant to the truck engineer, has been named assistant truck engineer in charge of administration.

D. J. LaBELLE, former head of the structural and suspension development department, has been appointed assistant truck engineer—development.

ROBERT E. WILSON has been presented the 1956 Washington Award, one of engineering's highest honors.

Wilson, chairman of the board of Standard Oil Co. of Indiana, received the award on May 1 for "unusual dedication of leadership in science and engineering and for advancement of research, industry and public affairs."

Sponsors of the award were the Western Society of Engineers, American Society of Civil Engineers, American Institute of Electrical Engineers, and the American Society of Mechanical Engineers.

GEORGE A. DELANEY, 1956 SAE president, says:

"We must continually be revolutionizing our conclusions of the past . . . in the light of new conditions, materials, and customer needs."

- x -

"Manufacturing processes must be coordinated and evaluated during the very first stages of product design."

President Delaney, chief engineer of Pontiac Motor Division, GMC, made these statements at a Philadelphia Section meeting on April 12, 1956.

ROY C. INGERSOLL has been named chief executive officer of Borg-Warner Corp. He will continue in his position as chairman of the board. He has been a director since 1930.

In keeping with his new duties, he will no longer serve as president, a position he has held for six years. Prior to becoming president of the corporation in 1950, he was a vice-president of the corporation and president of its Ingersoll, Franklin, and Calumet Steel Divisions.

GEORGE C. CAMPBELL is now service engineer in charge of the Detroit office for Metal Parts & Equipment Co. He has been a sales engineer for Gemmer Mfg. Co.

HOWARD L. WILLETT, JR. has been named president of The Willett Co., succeeding his father Howard L. Willett, Sr., who becomes chairman of the board. Willett, Jr. has been president of Willett Truck Leasing Co. and executive vice-president of The Willett Co. for a number of years. He was SAE vice-president representing Transportation & Maintenance Activity in 1954 and continues to play an active role as a member of the T & M Activity Committee.

JAMES B. KEATING succeeds Howard L. Willett, Jr. as president of the Willett Truck Leasing Co. Previously he was a vice-president of the Willett Co. and general manager of the Willett Truck Leasing Co.

Howard L. Willett, Sr. who has supported the SAE and has attended many meetings as a guest has been promoted to chairman of the board of The Willett Company.

Noble is 1956 Outstanding Young Engineer

CHARLES F. KETTERING (right), director and research consultant, GMC, makes the 1956 annual presentation of the Engineering Society of Detroit's Award to An Outstanding Young Engineer to **RUSSELL R. NOBLE**, Chrysler Corp. Noble is chief engineer, truck design development, Chrysler Engineering Division.

NEIL MacCOULL has become an independent consulting engineer and will continue as a lecturer in Columbia University's graduate school, following his retirement from The Texas Co. on March 1, 1956. He had completed 37 years with Texas and was consulting engineer on the administrative staff of its laboratories at Beacon, N.Y. He had charge of laying out and installing Texas' first engine testing laboratories at Long Island City and was the first supervisor of the laboratories after the move to Beacon.

MacCoull has contributed vastly to SAE throughout his 39 years of membership. He is a past-chairman of Metropolitan Section, served on the Research Committee from 1927 to 1942, and is the author of 17 technical papers. He has made major contributions in the areas of CRC interests.

His lectures at Columbia are on "Comparative Internal Combustion Power Plants." His address is Box 103, Fishkill, N.Y.

KENNETH R. HERMAN, SAE Detroit Section chairman for 1955–1956, served as presiding officer at the "Germany at the Crossroads" luncheon of the Economic Club of Detroit.

Subject of the luncheon, held April 2, was "After Adenauer—What?" presented by James K. Pollock, Ph.D., president of the International Political Science Association, Geneva.

Herman is president and general manager of Vickers, Inc., and a director of Sperry Rand Corp.

ALBERT I. ALSTROM has become manager of flywheel magneto sales for the Wico Electric Co. For the past year he has been serving as executive sales engineer, handling the engineering phase of sales, and previous to that he held the position of product engineer.

EDWARD A. FOSLER has taken the position of supervisor of quality control engineering for Chrysler Corp.'s Missile Branch. He has been supervisor of quality control for Studebaker-Packard Corp.

JOHN J. CASEY has joined the staff of aircraft consultant **R. DIXON SPEAS** at La Guardia Airport.

Casey has resigned from American Airlines, Inc., where he served as assistant vice-president—Maintenance. He joined American Airlines after World War II as manager of engineering for the Cargo Division.

D. R. FREY has been appointed manager of the industrial oil sales department of Deep Rock Oil Co.

Frey has been manager of products application department, heading the research laboratory at the Cushing refinery. He has been transferred to company headquarters in Oklahoma City.

P. R. DOWDEN has resigned his position as chief, preliminary design section, Canadair, Ltd., to serve as an engineering consultant for Hiller Helicopters, Inc.

L. D. CRUSOE, Ford Motor Co. executive vice-president—car and truck divisions (left), accepts the annual Motor Trend Award presented by Robert E. Petersen, Los Angeles publisher. The award is presented by Motor Trend Magazine to the automotive manufacturer "making the most significant advancement on a United States production car."

Berry, D. W.

Newton

Heinen

Whitlock

D. W. BERRY has been assistant chief engineer, Aviation Gas Turbine Division, Westinghouse Electric Corp. since late last Fall. Before taking this newly created position as assistant to chief engineer **ALAN CHILTON**, Berry had been with Ford as assistant chief engineer in its Chicago aircraft engine plant.

GAYLORD W. NEWTON, former chief of the Engine Test Facility, ARO, Inc., has been named manager of applications engineering in General Electric's Aircraft Nuclear Propulsion Department.

Newton has been associated with the aircraft industry since 1929 when he joined the Civil Aeronautics Commission. Chief of the powerplant unit for the Commission from 1934–1941, he left this post to become powerplant chief for Boeing Aircraft. In 1951 he became chief of the major research, development, and testing facility at ARO, Inc., the Arnold Engineering Development Center in Tullahoma, Tenn.

He was SAE vice-president representing Aircraft Powerplant Activity in 1954.

JOHN W. CLARK has been transferred to Chevrolet Motor Division, GMC, in the position of development engineer in the passenger car development section. He has been senior project engineer, Experimental Engineering Department, General Motors Proving Ground.

LOUIS J. AURE has been appointed to the newly created position of chief engineer, in charge of new products and design for Pressed Metals of America, Inc. He had been with Ford Motor Co. as chief product and design engineer for front ends.

JOHN J. HARTZ has been named development manager for all tire manufacturing divisions at Goodyear Tire & Rubber Co.

In his new assignment, Hartz will oversee all phases of the company's tire development and compounding programs.

He has been assistant to the director of engineering, tire development.

HAROLD D. CONNELLY is now a fleet engineer with Berman Service, Inc., Allentown, Pa. He had been a field supervisor for Electric Auto-Lite Co.

CHARLES M. HEINEN has recently been promoted to assistant chief engineer of the Materials Laboratories, Chrysler Corp. He has been assistant manager—engineering, Chemical Engineering Laboratories, for the company.

Heinen is the 1956 chairman of SAE Fuels and Lubricants Technical Committee.

MARVIN J. WHITLOCK, vice-president, maintenance and engineering, American Airlines, Inc., has been named to head a new division within the company's operations department to concentrate on operational planning for future aircraft.

He will move to the airline's General Office in New York City from Tulsa, where he was in charge of the airline's overhaul base.

JOHN J. CAMPBELL, formerly a design engineer for Oliver Corp., is now serving in the same position with Caterpillar Tractor Co.

D. BARKER BATES has been named to direct the newly formed industrial design section of the Engineering Division, Canadair, Ltd., a subsidiary of General Dynamics Corp.

The main responsibilities of the new section are to plan and design promotional material for the company. One of the jobs was the planning, in collaboration with plant engineering and public relations, of Canadair's display at the Explorama seen at the Show Mart, April 4–14.

ROBERT COWELL, who has been serving as a senior layout man for Chevrolet Motor Car Division, GMC, is now serving in the same position with Cadillac Motor Car Division's Cleveland Ordnance Plant.

MELVIN L. ARMBRUSTER is now an electrical-mechanical engineer for Douglas Cramer & Associates. He has been a liaison engineer with American Machine & Foundry Co.

ROBERT ANDERSON has been appointed chief engineer of Plymouth Division, Chrysler Corp. He has been a body engineer for the corporation.

HOMER P. COFFIN, formerly a buyer of casting, forging, and machined parts for Chrysler Corp. Delaware Tank Plant, is now at the jet engine plant in Detroit as a product engineer.

Obituaries

ANDREW L. POMEROY

Andrew L. Pomeroy, associate staff director, Research and Development, Thompson Products, Inc., died in Cleveland Clinic Hospital, May 10, after a short illness. He had been a leading figure in many SAE activities since 1943.

He was SAE 1956 vice-president representing Aircraft Powerplant Activity. He held further responsibilities as the SAE Chairman of the Nuclear Energy Advisory Committee, watching atomic developments with an eye to stepped up activity for SAE in that area.

He has explored the atomic energy field for Thompson Products, Inc. since last fall, when he was appointed to spearhead the formation of a Central Staff Study Group on atomic energy.

Pomeroy was born March 11, 1914 in Philadelphia. He studied aeronautical engineering at William Penn Aviation School and mechanical engineering at both Drexel Institute of Technology and the University of Pennsylvania.

His first job was in the Research and Development Department, Atlantic Refining Co. in Philadelphia from 1937 to 1943.

In 1943 he moved to Fairchild Engine and Airplane Corp., where he served as manager of engineering operations for the Ranger Aircraft Engines Division.

He joined Thompson Products in 1947. He first was staff engineer in charge of the Dynamometer Laboratory until 1950. He was director of development from then until 1951 when he became acting manager of the Electronics Division. In 1952 he was named associate director, Central Staff Research and Development, the position he held at the time of his death.

Pomeroy had been a member of the Meetings Committee. He was active on the Coordinating Research Council, serving for years as leader of the Detonation Testing, Full Scale, CRC Project. He had recently been appointed SAE representative on the American Standards Association Planning Committee on Standardization in the Field of Nuclear Energy.

SECTIONS

JUNE 1956

Student Summer Placement Strikes a Welcome Response

—Ramsay R. Jackson
Faculty Adviser,
Tri-State College Student Branch

SAE Placement Service instituted a brand new placement program for students this year. And the results have been gratifying.

For the first time, summer job listings have been offered students in engineering by SAE. Any SAE Enrolled Student can participate by sending for the list of summer employment opportunities compiled at SAE Headquarters in New York. This list provides the positions available, the location, and a general description of requirements, salary, and benefits.

Tri-State College in Angola, Ind. has provided an excellent example of the reception this program has earned. The following item was printed in the student newspaper, "The Triangle":

"SAE Lists Summer
Job Opportunities

"Summer employment opportunities for students are being listed by the Placement Service of the Society of Automotive Engineers, according to Ramsay Jackson, faculty adviser.

"Employment opportunities are listed by type of job, location, and description of the work, with names of persons to whom applications should be sent.

"Included are such jobs as engineer trainees, engineering assistants, layout men, draftsmen, etc., in location varying from the west coast, the midwest, the south, and the east coast.

"Further information on these jobs may be secured from Mr. Jackson."

A very nice letter came in to headquarters from Ramsay Jackson commenting on the service. We quote him as follows:

"Your new program of summer employment for engineering students has been very well received by the students and its popularity is growing since the above mentioned article appeared yesterday. I am showing this article to industrial representatives who came here to interview prospects and so far all have agreed with me that it is an excellent opportunity for industry and the student alike.

"On behalf of Tri-State College, the students enrolled in SAE, and myself, I want to thank you and your society for providing us with an interesting and useful service."

March Membership Applications Top All Previous March Records

In March, more men applied for membership in SAE than in any other March in SAE's history, and April was the second best April.

This significant bit of news comes from the Society's Membership Department.

The total figure for March was 249, topping the 1946 record of 242. In April 236 applications were counted, as against the record for the month of 250 in 1945.

MILWAUKEE

J. W. Mohr, Field Editor

Section Engineers Double As Milwaukee Math Teachers

Talks about the importance of mathematics and its applications to engineering were presented April 11–14 by volunteer Section members to Milwaukee suburban high school classes. In conjunction with the American Chemical Society, SAE members replaced teachers who were attending a convention of the National Council of Teachers of Mathematics.

F. T. Esty, chief engineer, Wisconsin Motors Corp., and members of the Section Governing Board, made the arrangements for the engineers and the schools. Esty assigned the following members to schools in the area:

Bernard Weber, Fulton Co.
J. R. Harkness, Briggs & Stratton Co.
George B. Luhman, Heil Co.
Louis Frank, Trackson Co.
James Mohr, Outboard, Marine & Mfg. Co.
Paul W. Eells, Thermoid Co.

DETROIT

W. F. Sherman, Field Editor

Section Picture Takes Shape From Questionnaire Responses

The major concern these days of the Long Range Planning Committee has been analysis of questionnaire results and studies intended to produce important recommendations for the Detroit Section Governing Board. Heading this paramount project is Whitney Collins, chief engineer, Gas Turbine Division, Continental Aviation and Engineering Corp. (See previous story about Long Range Planning Committee, SAE Journal, December 1955, page 94.)

On behalf of the Long Range Planning Committee, Collins recently presented a progress report to the Detroit Section Governing Board. The comprehensive analysis of the questionnaire data has been delayed slightly as the result of some tabulation difficulties, Collins reported, but the response to the questionnaire and the

CONTINUED ON PAGE 107

Tri-State Tours Clark Equipment Co.

Three scenes along the route of the Tri-State Student Branch tour through Clark Equipment Co.'s testing facilities. In the lower photo, Student Branch Adviser R. R. Jackson appears in the upper right corner with dark rim glasses. Student Branch Chairman Lloyd Gardner stands second from the right in the front row.

Western Michigan

W. A. MacLaurin, Field Editor

Winners to Reap Laurels In Technical Essay Contest

—Edward Wickland

May 15 climaxed the 1955–1956 student activity of the Western Michigan Section, when the winners of the Student Technical Essay Contest received their prizes at the annual Father and Son Banquet.

This is the fifth year that a technical essay contest has been sponsored and the largest number of participants were involved. Two schools have been participating: Grand Rapids Junior College and Muskegon Community College.

Western Michigan Section believes

CONTINUED ON PAGE 103

SAE Student Branch Outside Of Section Territory

Tri-State College Student Branch sponsored a field trip with the ASME Student Branch through Clark Equipment Co. testing laboratories, Axle Division. SAE member **Howard Felder**, head of the Physical Properties Laboratory, greeted the group and gave a brief description of processes used in manufacturing products such as axle housings, differential assemblies, and transmissions. He also explained the necessary part testing labs play in proving these products safe and durable.

Felder was aided in operating and explaining various displays along the tour by **David Hanson** and **Michael Chucta**, both Clark Equipment Co. engineers, SAE members, and Tri-State alumni.

More than 100 students took advantage of the opportunity to tour the plant.

Section Meetings

CANADIAN

June 21 . . . Annual Golf Meeting. Kitchener, Ont., Canada. Dinner 7:00 p.m.

CLEVELAND

June 14 . . . Annual Golf Outing at the Elyria Country Club.

METROPOLITAN

June 22 . . . Dinner and Dance on board Circle Line Boat. Cruise on Hudson River, Pier 83, Hudson River. Leaving Time 8:00 p.m. Ticket Price $10.00 per person.

that sponsoring technical essay writing to beginning engineering students will create an interest in automotive engineering early in the student's career.

A total of 95 papers were written on subjects pertaining to automotive or aircraft industry, such as materials, production, design development in connection with transportation, farm machinery, and industrial engine applications.

To achieve the widest distribution of cash prizes, each school had a first, second, and third prize winner as selected by a panel of faculty members from each college. Prizes go to the three prize winners from each school and in addition a prize is awarded to the best of the six papers as judged by a panel of SAE members.

Writing technical papers, whether a prize is won or not, is valuable training for any engineer. So, in one sense there are no losers. The participants in today's student essay contests may well be the writers of tomorrow's SAE papers.

PITTSBURGH

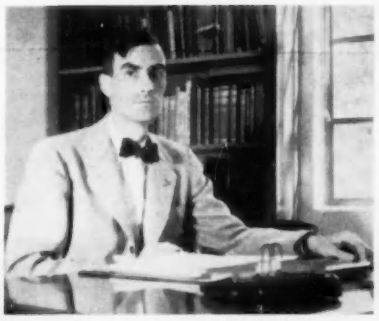
W. C. Weltman, Jr., Field Editor

"The Horsepower Race and Car Economy" won first place for **William C. Helsley**, Student Branch member from the University of Pittsburgh, in the Section Student Technical Paper Contest. Second prize went to **Charles E. Devlin**, Carnegie Institute of Technology, for his paper, "The Amazing Volkswagen Engine." Out of a possible maximum of 600 points, only two points separated these first and second place papers. Each will appear in an abridged form in a forthcoming issue of SAE Journal.

Presentation of the competing papers was made at the Section April 24 meeting. Honorable mention awards went to **Robert L. O'Brien**, Carnegie Tech, and **John Marcosky**, University of Pittsburgh.

So. California

W. E. Achor, Field Editor



Peter Kyropoulos served as chairman of SAE Southern California's recent seminar on Frontiers in Automotive Engineering. His efforts resulted in three sessions, each drawing a large and deeply interested audience.

Kyropoulos is an associate professor of mechanical engineering at California Institute of Technology. SAE Journal erred in saying he was on the faculty of California State Polytechnic College in the April issue.

C. F. Keene, SAE member since 1919, wrote a humorous poem concerning present automobile quality, called "Our Automobiles." It was read to the Southern California Section by **Jud Pickup**, sales engineer for Champion Spark Plug Co., at the March 12 meeting.

Two special guests attended the April meeting of **California State Polytechnic College Student Branch.**

Thomas H. Hardgrove, former instructor who helped form the Student Branch at Cal Poly, was present. He is now a plant engineer with Aerojet-General Corp.

The other guest was **Robert G. Reichmann**, 1954–1955 chairman of the Student Branch. He is also employed with Aerojet-General Corp.

No. California

L. J. Abell, Field Editor

Northern California Section featured Darl Caris, head, Automotive Engines Department, Research Laboratories Division, GMC, as speaker at the April 25 meeting.

No. California Section South Bay Division

Hints From South Bay On a Date For Ladies' Night

A 3-man committee was appointed by South Bay Division to set a convenient date and place for the Division Ladies' Night festivities. To avoid conflicts with local school or college functions, this committee, appointed by the Division officers in January, contacted the grammar schools, colleges, and universities in the area to get the dates of school functions scheduled during the first half of June.

From these data, the committee selected the most favorable date in sufficient time to obtain reservations for a meeting place.

Earl Lenz (left) and son, Robert, each take an active part in Buffalo Section meetings and Governing Board activities. Earl is Program Committee chairman. His son is Meetings and Arrangements Committee chairman.

Bill Evans, chairman of the San Diego State College Student Branch, tells guests about SAE and its advantages at the Second Annual Greater San Diego Science Fair, April 6–10.

BUFFALO

Dudley Losee, Field Editor

Buffalo and Its Division Follow a Profit-Sharing Plan

The Buffalo Section and its Rochester Division activities have been carefully integrated so that the Division can work toward Section status, and the Section can contribute toward this end.

Attendance at the Rochester Division meetings is encouraged by making some of the Section meetings joint Section-Division meetings. These joint gatherings are planned and arranged by the Division's committees.

Geographically, the Buffalo Section and Rochester Division are close enough to make attendance at each other's meetings practical. This arrangement provides the Division with the opportunity to plan larger meetings, thereby attracting more interesting speakers. This in turn attracts more engineers from within the Division's territory.

This year, the joint meetings on "Road Racing and Its Influence on Automobile Design," and a plant tour of the Massey-Harris-Ferguson Corp. plant in Batavia were well attended and very successful.

Buffalo Section Rochester Division

Rochester Division of Buffalo Section sponsored a panel discussion on Rochester's past and present contributions to the automobile industry as a feature of its March meeting. Antique cars and automotive products manufactured in Rochester were displayed at the Rochester Museum of Arts and Sciences in connection with the meeting.

E. F. DeTiere, Jr., regional vice-chairman for Rochester for Buffalo Section, was in charge of the meeting and displays.

Examining a 1905 Reo at the March meeting of Buffalo Section's Rochester Division are (left to right): Henry R. Selden, former chief engineer of the Selden Motor Vehicle Co.; James E. Gleason, chairman of the board of Gleason Works; A. J. Cunningham, who built the Cunningham Car with his father in Rochester in the early 1900's; Arthur C. Lohman, president of the Rochester Association of Automobile Dealers; Dr. Blake McKelvey, Rochester historian; Howard C. Jones, director of manufacturing, Consolidated Vacuum Corp.; Dr. John H. Remington, president, Genesee Valley Antique Car Society; and E. F. DeTiere, Rochester Products Division, GMC, and regional vice-chairman for Buffalo Section.

Mid-Michigan

G. W. Colby, Field Editor

How To Make Section Advertising Pay

The engineer who becomes Advertising chairman for a Section often finds himself in a strange world. Normally familiar with terms like precession torque, charge-dilution, modulators, flame propagation, bounce and pitch centers, and the like, the neophyte huckster suddenly is up to his ears in electrotypes, rotary, offset, and flat bed presses, cuts, copy, Gothic, 70# enamel, and other mystic jargon of the press. After spending a few hours with a patient printer, he can take a deep breath and plunge into his manifold duties.

In the Mid-Michigan Section, the Advertising chairman is responsible for all advertising, including the Mid-Michigan Section Yearbook, meeting tickets and program announcements. In addition, he is responsible for the printing of tickets and program announcements. Advertising on the tickets and announcements must pay for the printing, postage, mailing envelopes, cuts of the speaker, and any other incidental expense.

Solicitation of company sales managers or advertising managers by mail is the usual method of obtaining advertising, because the chairman is necessarily limited in time to devote to his duties. Very often a territory salesman can be solicited and presented with a form letter to take back to his superior. It is almost imperative that a sample of a previous publication also be enclosed for his reference. This personal solicitation seems to be more effective than solicitation by mail. The form letter should contain all data relative to rates, size of publication, closing date, date of publication, and extent of distribution. Plates should be requested, if available, to reduce time consuming correspondence and any misunderstanding relative to the copy and layout. A letter of appreciation, with copies of the publication carrying the advertiser's message, always is sent to the agency and the advertiser.

Advertising Chairman Bob Trembeth deserves a bouquet for the results he has obtained in promoting the use of advertising in Mid-Michigan publications.

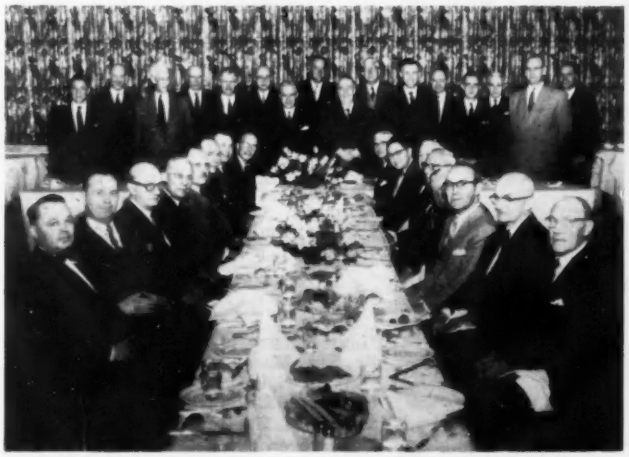
CANADIAN

F. G. King, Field Editor

New Members Night at Canadian Section was treated to a visit by **SAE President George Delaney** as speaker on "Designing an Automobile." A special invitation was extended to 52 new members of the Section to be on hand to greet President Delaney, and a large percentage were there to welcome him and be welcomed themselves.

Goodyear Tire & Rubber Co. of Canada, Ltd. supplied a very impressive welcome sign to decorate the hall.

Delaney had been feted with a Governing Board luncheon that afternoon, during which he was presented with the traditional cane umbrella by **Warren B. Hastings**, a past-chairman of the Section.



President George A. Delaney (standing fifth from the left) was treated to a luncheon at the Granite Club by all the members of the Canadian Section Governing Board. He was also presented the traditional cane umbrella.

CINCINNATI

H. E. Pitzer, Field Editor

Trailmobile Trailer Co. was host to Cincinnati Section members April 30. A combined business meeting and plant tour were held at the Cincinnati plant.

An introductory talk on Trailmobile's "Customer Individualized Design" program was provided by the assistant general sales manager, Jack R. Kruizenga.

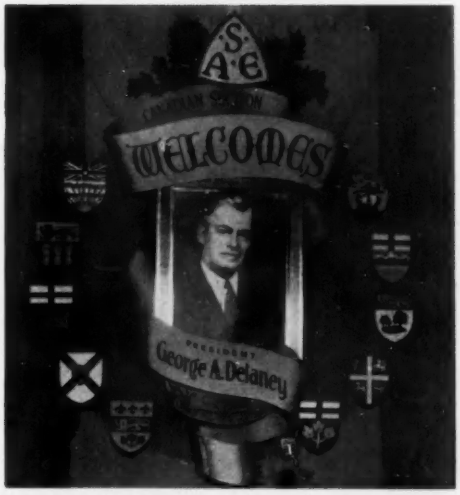
Then the tour began under the direction of SAE members: **W. R. Hummel**, Trailmobile's chief engineer; **W. L. Suire**, chief product engineer; and **P. J. Jung**, development engineer. The trip took them through the machine shops, the final assembly lines, the testing and inspection lanes, and the development department. Jung explained a number of the stress analysis tests and exhibited the test equipment trailer used for those tests. He also ran through a demonstration test on the equipment.

The May meeting brought to a close the University of Cincinnati Student Technical Paper contest as the winning paper was presented before the Section.

R. G. McCullum's paper on "Shell Molding" won the first prize. The judging was done on April 15, and was based on the following:

1. Technical accuracy
2. Amount of time required to accumulate data
3. Complete coverage of subject, and
4. Interest ability.

A technical digest of this winning paper has been included in this issue of the Journal on page 116.



Canadian Section sported an impressive welcome sign for SAE President George A. Delaney at the March 21 meeting. It was provided by the Goodyear Tire & Rubber Co. of Canada, Ltd.

Central Illinois

Harlan Banister, Field Editor

J. D. Loftis, Chicago, Rock Island & Pacific Railroad Co., points out special features of the Rock Island "Jet Rocket" train to Central Illinois Section members on tour. Left to right are: W. C. Cadwell, Section program chairman; J. W. Gilbert, Section vice-chairman—Arrangements; Loftis; and J. E. Mitchell, technical chairman for the Feb. 27 meeting.

March 19 brought the annual celebration of Student Night at Central Illinois Section. **Section Chairman R. V. Larson** turned the meeting over to **Student Activities Chairman R. D. Henderson** and the Student Branches from the University of Illinois and Bradley University.

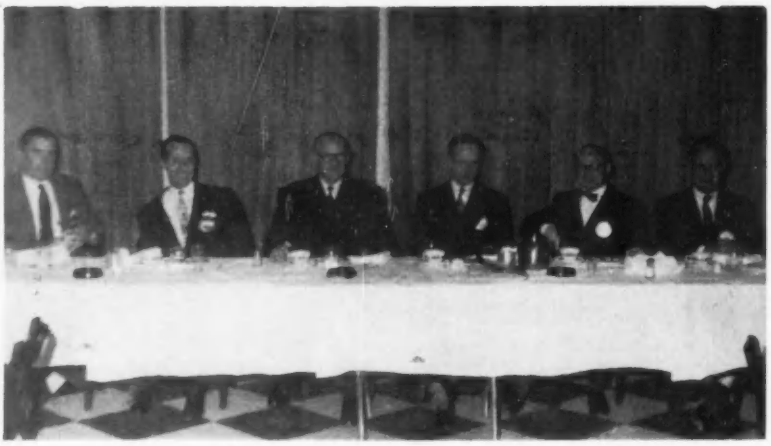
Richard Banter, University of Illinois, and **Herbert Fenske**, Bradley University, were appointed to serve as technical chairmen for the program.

Speakers for the evening, competitors in the Student Technical Paper Contest, included: **Ronald Brennan**, Bradley University; **James Bueche**, University of Illinois; **Ellis Schmidt**, University of Illinois; and **Robert Johnson**, Bradley University.

"P-V Diagrams for High Speed Engines" by James Bueche received first-place award. Ellis Schmidt's paper, "Fuel Injection for Automotive Type Gasoline Engines," won second-place award. The remaining two presentations each received presentation awards.

SAE Journal will handle the available papers from the above in abridged form in a forthcoming issue.

Principals in Central Illinois Section's Student Night featuring the Student Technical Paper Competition included: Standing left to right: R. D. Henderson, Section Student activities chairman; Richard Banter, University of Illinois, a technical chairman for the evening; Ronald Brennan, Bradley University, a speaker; and R. V. Larson, Central Illinois Section chairman. Sitting left to right: Herbert Fenske, Bradley University, another technical chairman for the event; James Bueche, University of Illinois, a speaker; Ellis Schmidt, University of Illinois, a speaker; and Robert Johnson, Bradley University, a speaker.



Honored guests at the Washington Section March 20 meeting included (left to right): L. C. Kibbee, Section treasurer; J. C. Fielding, Section secretary; J. H. Hartzenbusch, speaker from Volkswagen Co. of America; M. W. Snider, Section chairman; Robert Burkhardt, Section meetings chairman; and John Hulse, 1952–1953 Section chairman.

DETROIT

W. F. Sherman, Field Editor

continued from page 101

data being derived from the responses are extremely gratifying.

The committee received a total of 2,317 replies, of which 2,280 arrived in time for tabulation. This represents a response of more than 53% of the Detroit Section membership as of September 1, 1955.

The results were thoroughly representative of the Detroit Section membership:

Of the registered Juniors 49% replied to the questionnaire and 54% of the Members and Associate Members replied.

The response proved that, of the group replying, 55% are engaged in product engineering activities directly; only 19% are in sales engineering or related activities.

Preliminary interpretation by the committee treats this as a very worthwhile piece of information.

With regard to major technical interests, 63% checked passenger car; 37% selected vehicle power plants (for which there is no separate SAE Activity); 31% checked truck and bus. The remaining interests received generally between 10 and 20% of the response, with the exception of air transport which proved to be not very interesting to members in the Detroit area, with only a 2% response. In view of the type of industry activity in Detroit, this response was not a surprise.

Analysis of replies pertaining to meeting attendance showed that some individuals checked meetings as "attended" when in fact they only had the intention or desire to attend. Thus the total attendance at any given meeting for this group is probably slightly over-stated. However, the 2,280 responders indicated that they had attended a total of 3,317 meetings of the Detroit Section during the previous operating year, for an average of 1.45 meetings per member. Based on actual meeting attendance statistics (door count) the average member attended 1.37 meetings during the year. This information correlates well, indicating that the sample, while admittedly large, is also extremely representative, and therefore worthy of very detailed examination.

On type of meeting desired, the responses indicated broad support for the general interest, dinner type of meeting Detroit Section has had in the past. It is evident, however, that a large minority group is extremely interested in more technical type meetings. A surprising aspect of the response was the relatively large number who indicate they are in favor of small, informal meetings. Further analysis of these replies is being attempted to develop information that will more definitely identify this group and possibly elicit ideas on how they can be better satisfied.

A large number of members checked both types of meetings, whereas others expressed no opinion whatsoever in their response to the questionnaire.

In the preliminary analysis the breakdown is as follows:

General interest meeting	56.3%
Technical meeting	33.9%
Technical and general interest	3.0%
No expressed opinion	6.8%

Social activities were considered as adequate by 79% of the group responding, but about 13% thought the amount of social activity should be increased.

Approximately 200 questionnaires contained comments written in by the responder. Many of them were very interesting and some, Collins comments, were "most sage." The write-in comments are being regarded by the committee as particularly significant, even though they do not count statistically in any of the tabulations. The committee has analyzed these write-in comments and broken them down into general categories as follows:

Lower cost social activities	24
More technical content in meetings	19
Miscellaneous suggestions on different types of meetings	10
Type of meeting depends on subject	9
Suggestions on social activities	9
More field trips	4
Smaller, more frequent meetings	4
Less sales effort by meeting speakers	3
Accommodations too small, consider holding some meetings elsewhere	3
Miscellaneous	Remainder

Officers and members of the Governing Board regard this analysis effort on the part of the Long Range Planning Committee as one offering a great potential for future guidance on Section activities.

Oregon

Activity highlight for the year at **Oregon State College Student Branch** was a week's field trip to the San Francisco Bay area in April. The group covers many engineering operations in the Bay area each year on this trip.

SAN DIEGO

R. E. Day, Field Editor

San Diego Section cooperated by providing a display in the Second Annual Greater San Diego Science Fair held in the Conference Building, Balboa Park, San Diego, April 6–10.

W. L. "Bill" Evans, chairman of the Student Branch at San Diego State College spent many hours explaining the advantages of SAE to junior and senior high school students visiting the Science Fair.

Metropolitan

Leslie Peat, Field Editor

City College of New York Student Branch celebrated its annual social event April 13 at the College Finley Student Center.

A contest in unscrambling aircraft terms opened the festivities. The stickler turned out to be "ineroal"—aileron.

Other features included renditions of the SAE hit parade songs by the SAE-DETS. Number one was "Dean Phases," iron carbon, that is; number two was "16 Tests;" and number three was "The Greek Alphabet Song." Then a skit followed by the SAE Players. In "SAE Visits a Pizza Plant, ala Bert and Harry" members were introduced to the new standards for hardening, annealing, tempering, and testing Pizza. A favorite question during the skit was, "Do you hire needy engineering students for the summer?"

Guest speaker for the evening was CCNY Alumnus **Joseph Gilbert,** secretary of the SAE Technical Board and manager of the Technical Committee Division. He offered a talk on "Finding the Right Job."

Gilbert is an active member of the Man Marketing Clinic in New York City. He informed the Student Branch that many engineers five years out of school find themselves in the wrong field of engineering. He stressed the importance of graduates finding out which field is best suited to them, instead of going into the field which offers the most money or sunshine.

After his talk, announcement was made of the winners of the Branch airplane design contest. In the design field, first place went to **Ben Trasen** for a four placed, pusher type amphibian. In the field of safety, **Joseph**

CONTINUED ON PAGE 111

TECHNICAL COMMITTEE *Progress*

1956 SAE Technical Board

R. F. Kohr, Chairman
C. F. Arnold
B. B. Bachman
L. L. Bower
O. A. Brouer
A. T. Colwell
Trevor Davidson
F. W. Fink
W. H. Graves
W. M. Holaday
A. E. W. Johnson
W. C. Lawrence
A. G. Loofbourrow
E. F. Norelius
Harold Nutt
C. L. Sadler
A. E. Smith
D. D. Streid

Fuel Injection Mounting Subcommittee Tours Plant

Gathered around a large transmission case for a tractor are Alexander Dreisin of Micro-Precision, Inc.; W. C. Voight of Kohler; E. L. Stewart of Dole Valve; K. M. Cloud of Continental Motors; C. V. Brack of Bendix Aviation; N. Fodor; W. J. Gewinner of American Bosch; and R. Z. Farkas of Hercules Motors.

Subcommittee Chairman Robert L. Shallenberg (right) shows E. R. Migit a high alloy steel mixing chamber. Shallenberg is with International Harvester. Migit is with Imperial Brass.

HAVING completed standards on the mounting and connecting of diesel fuel pumps, the Fuel Injection Mounting Subcommittee has undertaken standardization of mountings and connections of primers for both diesel fuel and gasoline.

The standard on Mountings of Diesel Fuel Pumps first appears in the 1955 SAE Handbook and covered flange and base mounted pumps of the 4-, 6-, and 8-cyl variety. A new standard on mountings of "distributor type" pumps appears in the 1956 Handbook along with completed standards on fuel injection fittings and fuel supply fittings.

In developing standards for diesel fuel and gasoline primers, the Subcommittee aims to make dashboard mounted primers interchangeable from a dimensional and functional standpoint. This work includes the standardization of the mounting dimensions, the fuel inlet and outlet connections, and the location of the fuel connections with respect to the dashboard. Surveys are being made to determine the installation requirements in both original equipment production and field service replacement.

One of the main problems in this standardization work is the orientation and location of the fuel connections. Tubing connected to a replacement primer may be overstrained and broken through fatigue if the connection locations on the replacement differ from those on the original primer.

The Subcommittee met April 17 at the Melrose Park plant of the International Harvester Co. Part of the day was devoted to a tour of the plant.

Besides those shown in the photographs, the Subcommittee's membership includes E. F. Grimmeisen of Hartford Machine Screw Co., C. N. Guerasimoff of Buda, and W. E. Klatt of Waukesha Motor Co.

Winterization Needed For Tractors in Arctic

FOR service in Greenland, tractors need the best provisions for operation and maintenance in extreme cold that can be devised. This fact was emphasized to CIMTC Subcommittee XV on Winterization by R. M. Dully of Caterpillar, F. L. Good of Cleveland Trencher Co., and R. C. Navarin at a meeting held April 23–24 in Chicago. They had just returned from a tour of Greenland bases.

The Air Force uses big crawler tractors to draw supply sleds from the base at Thule to outlying radar and weather stations, they explained. Each tractor pulls three or four sleds, which may bear a total of 30 or 40 tons. In the train is a "wanigan" providing bunks, cooking facilities, and equipment for minor repair jobs.

Along the Greenland coast, temperatures reach 50 F in the summer, and the ice and snow melt, exposing rock. Inland on the ice cap, summer temperatures are only 15 F. Winter temperatures drop to −60 F and are accompanied by 85 mph winds and the darkness of a 24-hr night.

So the tractors operate over rock, frozen snow and ice, and soft snow, from the coast across the crevasse areas to the permanent ice cap. Center of the ice cap is 12,000 ft above sea level.

Snow that gets between moving parts wears them out just about the way sand does. And blowing snow plugs air cleaners even when they are run dry.

Add to these climatic difficulties the

Continued on page 110

Longwell addresses Ignition Subcommittee

Subcommittee Chairman Lawrence R. Lentz, Speaker J. P. Longwell, and Committee Chairman Charles M. Dean

"THE response of a combustor to ignition or changes in pressure and velocity depends very strongly on the type of flame existing in the combustor," Dr. John P. Longwell told the Aircraft Gas Turbine Ramjet and Rocket Engine Ignition Subcommittee at its April 10 meeting in New York. Longwell is assistant director of the Process Research Division of the Esso Research and Engineering Co.

Longwell explained that the basic types of flame are (1) the homogeneous combustion zone, (2) the diffusion flame, and (3) the premixed combustion wave.

The homogeneous combustion zone exists under conditions of intense mixing. Under these conditions combustion rate is limited by the chemical rate of reaction, Longwell said. At high altitudes and high combustor loading such as exist in some military equipment, blowout and ignition are limited by this chemical reaction rate so that understanding of this type of combustion is considered very important.

At low altitude the chemical combustion rate is generally not limiting and the combustion zone depends on the usual diffusion or premixed type flames.

Chairman of the Aircraft Gas Turbine Ramjet and Rocket Engine Ignition Subcommittee, which Longwell addressed, is Lawrence R. Lentz, Champion Spark Plug Co. Parent group of the Subcommittee is the SAE Ignition Research Committee, of which Charles M. Dean, Pratt and Whitney Aircraft, is chairman.

1956 SAE National Meetings

August 6-8
West Coast Meeting
Mark Hopkins Hotel,
San Francisco, Calif.

September 10-13
Tractor Meeting and
Production Forum
Hotel Schroeder, Milwaukee, Wis.

October 2-6
Aeronautic Meeting, Aircraft
Production Forum, and Aircraft
Engineering Display
Hotel Statler, Los Angeles, Calif.

October 10-12
Transportation Meeting
Hotel New Yorker
New York, New York

November 1-2
Diesel Engines
The Drake, Chicago, Ill.

November 8-9
Fuels and Lubricants Meeting
The Mayo, Tulsa, Okla.

1957

January 14-18
Annual Meeting and
Engineering Display
The Sheraton-Cadillac
and Statler Hotels,
Detroit, Michigan

March 5-7
Passenger Car, Body, and
Materials Meeting,
The Sheraton-Cadillac,
Detroit, Michigan

March 20-22
Production Meeting and
Forum, Hotel Statler,
Buffalo, New York

April 2-5
Aeronautic Meeting,
Aeronautic Production Forum,
and Aircraft Engineering Display
Hotel Commodore, New York,
New York

June 2-7
Summer Meeting
Chalfonte-Haddon Hall,
Atlantic City, New Jersey

TAYLOR

HI-EFF

Sensitive Precision Drilling Machines

New! New!

NOW! Taylor HI-EFF offers you a new "C" Series Sensitive Precision Drilling Machine priced *considerably lower* than the well-known "A" Series, yet containing most of the quality features found in the "A" Series machines.
Write for Bulletin 182.

AUTOMATIC FEED NOW AVAILABLE

Automatic Feed attachments for small hole drilling are now available for all Taylor HI-EFF "A" Series and "C" Series machines. Easily Adaptable!

TAYLOR DYNAMOMETER and MACHINE COMPANY

DYNAMOMETERS • BALANCING MACHINES
DRILLING MACHINES

6411 River Parkway, Dept. SA, Milwaukee 13, Wis.
INTERNATIONAL DIVISION — DUMMANN WORLD TRADE CO., Milwaukee 6, Wisconsin, U. S. A.

Winterization Needed for Tractors in Arctic

continued from page 109

fact that men are returned to the States after a year in the Arctic—which is not much more time than it takes to train a man thoroughly.

For these reasons, said Dully, Good, and Navarin, tractors need to be equipped to stand low temperatures and they must be easy to maintain. They suggested:

- Addition of a device to keep water out of fuel systems.
- Installation of the battery inside the cab, where it will be kept warm, rather than outside.
- Extension of tubing from service points to the exterior of the tractor to make lubrication easy. (If lubrication isn't easy to perform, it doesn't get done at all.)
- Installation of a hydraulically operated drawbar to assist steering and reduce wear on clutches and brakes. This has worked well on the tractors on which the drawbar has been installed.

Subcommittee XV is interested in Greenland experience not only because of the equipment used there but also because of similar tractors and other equipment now operating on a year-round basis in the Minnesota mining regions.

At the April 23–24 meeting, the Subcommittee laid plans to meet May 21 in Virginia, Minnesota, to discuss mining equipment problems. The group is a subcommittee of the SAE Construction and Industrial Machinery Committee.

Subcommittee Members

Serving on the Subcommittee are M. G. Mardoian, chairman, International Harvester Co.; W. W. Cornman, secretary, Allis-Chalmers; F. M. Baumgardner of the U.S. Army Corps of Engineers; R. J. Bernotas, Euclid; T. H. Fones, Caterpillar; G. H. Haines, Detroit Diesel; J. H. Hyler, LeTourneau-Westinghouse; G. W. LaSalle, Hercules Motors; M. R. Nicholson, Allis-Chalmers; H. M. Reichert, Waukesha Motors; J. K. Tomko, Oliver Corp.; and J. E. Wieshel, Heil Co.

SINCE 1907

PARK

QUALITY DIE FORGINGS

FROM VITAL AVIATION DROP FORGINGS TO DIESEL CRANKSHAFTS WEIGHING UP TO 4000 LBS.

THE PARK DROP FORGE CO.
Gordon Park at E. 79th. Cleveland 3, Ohio

Sections

Continued from page 107

Cereolo, who drew up plans for a passenger compartment on skids which could slide forward into the baggage compartment in case of a crash and thereby absorb most of the impact, came in first.

The film, "The SAE Success Story," was shown to complete the evening.

ALBERTA

William Fairhead, Field Editor

A tour of the new Willard Battery Co. plant in Calgary, Alberta, was the highlight of the Group's April 20 meeting. Production of storage batteries from start to finish was witnessed by the crowd.

Philadelphia

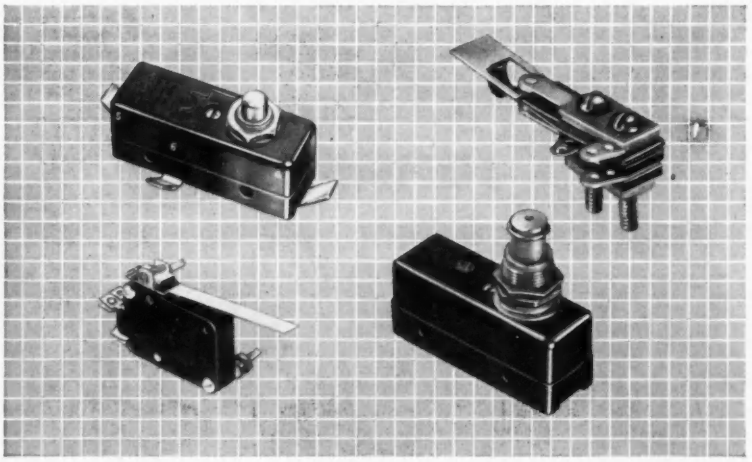
M. K. Simkins, Field Editor

A. **M. Miley** (1953–1954 Section chairman) bought the first two tickets for this year's Philadelphia Section Ladies' Night, May 11. He learned he was the first buyer *after* **Ladies' Night Chairman Leon Dumont** made the sale at the Social hour preceding the April 11 meeting. The party this year was at the Springhaven Country Club at nearby Swarthmore.

Texas Gulf Coast

April meeting of Texas Gulf Coast Section featured a round table discussion of automotive corrosion problems. This was the first meeting of this type that the Section has held. Reception of the program indicated that more meetings of this type will be featured.

NOW you can really put 12 volt batteries to work on power driven automobile accessories . . .



ACRO *precision* SWITCHES control highly inductive loads

You can use compact, powerful Acro precision snap-switches to actuate all electrically controlled, automatic devices in today's or tomorrow's cars. These micro switches will handle those heavy shock loads that are inherent to motors or solenoids.

You can get Acro switches in all shapes and sizes. They are available with convenient push-on terminals so widely used in the automotive industry. And they come in ratings up to 40 amps, 14 volts. There are hundreds of standard varieties from which to select. If necessary, our engineers will modify or even develop new designs to suit your requirements.

SUGGESTED ACRO SWITCH APPLICATIONS

Automatic Seats	Door Locking Devices	Remote Trunk Locks
Convertible Top Controls	Electric Wipers	*Or your new device*

Just send us your specifications or write for catalog

ACRO MANUFACTURING COMPANY

SWITCH DIVISION
Columbus 16, Ohio

Plants at Columbus and Hillsboro, Ohio
DETROIT OFFICE: 2463 National Bank Bldg., Walter F. Rockwell

Averages Fall Short In Guiding Car Design

Based on paper by

CARL REYNOLDS
Chrysler Corp.

DEVELOPING a passenger car package is a science which still has a long way to go. It starts with a study of passenger characteristics—you determine his average size, his habits of travel, and the size of families.

After you have acquired a pretty clear picture of the ultimate user and his habits, you have to determine what he can pay and how many cars which meet average needs can be sold. From this information car specifications can be drawn up to provide suitable space and comfort, all packaged with taste to appeal to this average consumer.

When this procedure has been followed in detail and the statistical car takes on form and substance, how does it compare with popular cars of today? It doesn't conform. In fact, there is a surprising difference. This discrepancy cannot be traced to unscientific procedure, but rather to the use of averages. The average does not provide for the extremes in consumer requirements which apparently must be satisfied. American customers are so rich and have such a range of decisions, or choice, in their buying that they baffle marketing experts and economists.

Stylists must now learn still more about how to transport these statistical people rapidly in comfort, convenience, and safety, and more about satisfying their real needs.

(Paper "Passenger Car Package Development is a Science" was presented at SAE Passenger Car, Body, and Materials Meeting, Detroit, March 6, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

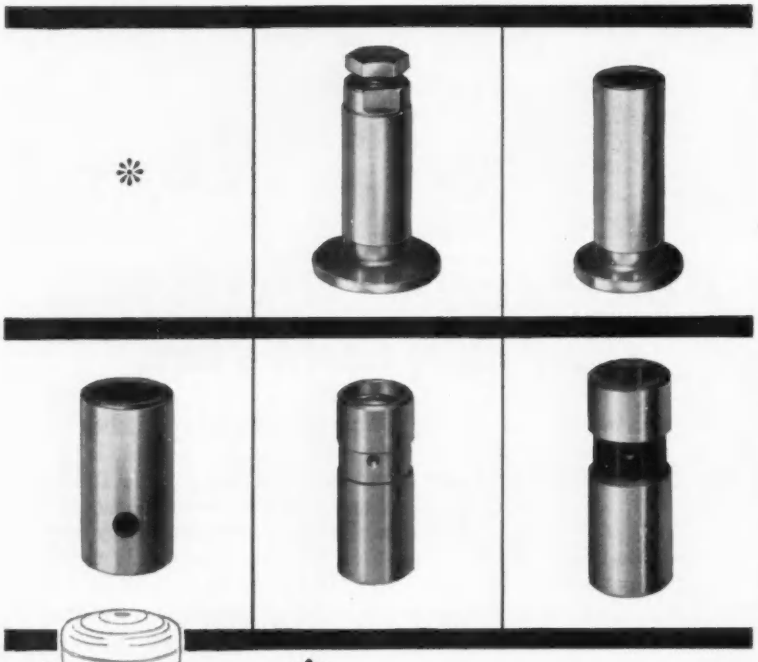
Based on Discussion

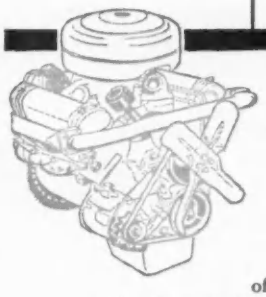
Harry Chesebrough
Chrysler Corp.

The package that succeeds appears to be one whose length and wheelbase, width and height are just long enough, wide enough, and high enough to "reach the customer"—no matter what his age, size, or station in life may be. In effect, the factors which we feed into our formula are still very much subject to interpretation. But perhaps it is better this way. If the day should ever come when the buying habits of the motoring public could be predicted with any degree of accuracy, the results might just possibly not please us at all.

The scientific package development is a tool to be used as any skilled craftsman uses a tool: with discrimination, judgment, and experience.

JOHNSON *tappets*





keep pace with today's engines

Continual experimentation and excellent manufacturing methods show a steady product improvement that make JOHNSON TAPPETS worthy of your consideration. Only proven materials, covering a range of steel, chilled iron, and various iron alloys are used in the manufacture of JOHNSON TAPPETS, providing greater strength, light weight and increased wear resistance. Serving the AUTOMOTIVE — AIRCRAFT — FARM — INDUSTRIAL — MARINE Industries.

"tappets are our business"

JOHNSON JP PRODUCTS
MUSKEGON, inc. MICHIGAN

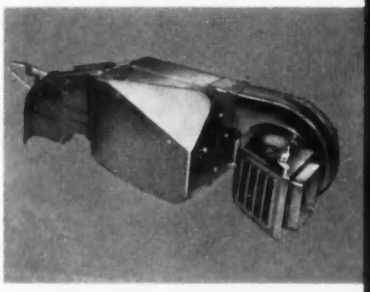
Experts Tell Controls For Gear Production

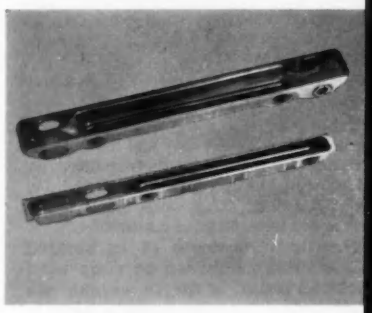
Based on report by

E. T. CHAMPLIN
Allis-Chalmers Mfg. Co.

BASIC to the production of quality gears cut or forged from steel billets or bars is the choice of material. When the exact type or grade of material has been decided upon, the purchase order should specify (1) chemical analysis, (2) grain size, (3) silicon content, (4) hardenability limitations, (5) quality, and (6) special mechanical properties where required.

Chemical analysis and grain size largely determine the hardenability level of the steel. Silicon content of 0.10 to 0.35% is necessary to deoxidize

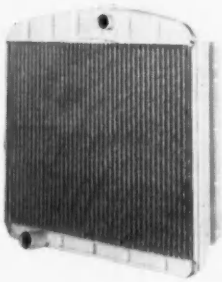


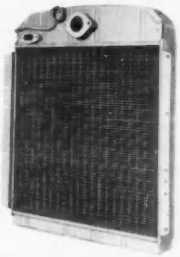


TEMPERATURES
MADE
TO
ORDER

Temperatures made to order!

Harrison covers the "Hot and Cold" market with a complete line-up of automotive temperature controls!





Tailor-made temperatures are Harrison's stock in trade!
Harrison's all-around heat control means greater comfort and convenience with "out-in-front" air conditioning in summer . . . efficient heaters in winter! And Harrison radiators, thermostats and oil coolers assure peak engine and transmission performance. Leading car and truck manufacturers specify Harrison—with over 45 years' manufacturing experience and the most complete engineering research facilities in the automotive heat-transfer field. If you have a "hot" or "cold" problem, look to Harrison for the answer.

HARRISON RADIATOR DIVISION, GENERAL MOTORS CORP., LOCKPORT, N. Y.

HARRISON

Fabricon Reinforced Plastic Moldings permit GREATER FREEDOM OF DESIGN!

Take a good look at many of today's smart new automobiles and you'll find that an amazing number of parts are now being made of reinforced plastics . . . *custom molded by Fabricon!* Heater housings, seat back panels, bonding strips, garnish moldings, just to name a few. What's more, if you look around, you'll also find that Fabricon reinforced plastic moldings are playing an increasingly important role in the design and manufacture of many other products, too. And for very good reasons!

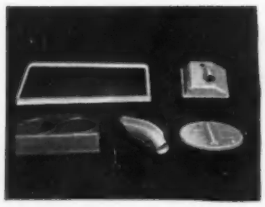
1. Because the premix compounds are scientifically developed and produced by Fabricon to meet the specific requirements of each individual application.

2. Because basic materials selected are processed by Fabricon's special laboratory controlled methods to assure proper distribution of fiber reinforcements throughout each finished molded part.

3. Because the greater uniformity of physical characteristics thus obtained permit the use of Fabricon reinforced plastic moldings on countless applications generally considered impractical or, indeed, impossible just a few short years ago. And . . .

4. Because ease of molding plus *lower tooling costs* permit efficient, economical production of intricate, complex parts. Parts which require no costly secondary or assembly operations . . . which in turn invariably permits greater freedom of design!

Complete facilities for the development of new products and processes for you!



Want detailed information on Fabricon products and services? Write today!

FABRICON PRODUCTS
A Division of The EAGLE-PICHER Company
1721 W. PLEASANT STREET
RIVER ROUGE 18, MICHIGAN

Reinforced Plastic Moldings • Plastic Impregnated and Coated Materials

gear steels as a preliminary to adding aluminum for controlled grain size. As such, parts made from a "silicon-killed" heat of steel react more uniformly when heat-treated. The steel "quality" requirement depends as much on manufacturing operations as it does on the ultimate function of the parts.

When it comes to cutting gears there is no substitute for good tooling. All gear cutting machines should be kept in good repair. New machines or a first class repair job cost money, but the outlay is justified in the long run. Runout and wobble in gear blanks should be watched for when cutting helical gears, whereas teeth spacing and runout are the things to keep an eye on when cutting spur gears. The best way to detect a worn shaving cutter is not by the tool but by involute checks on the machined gear.

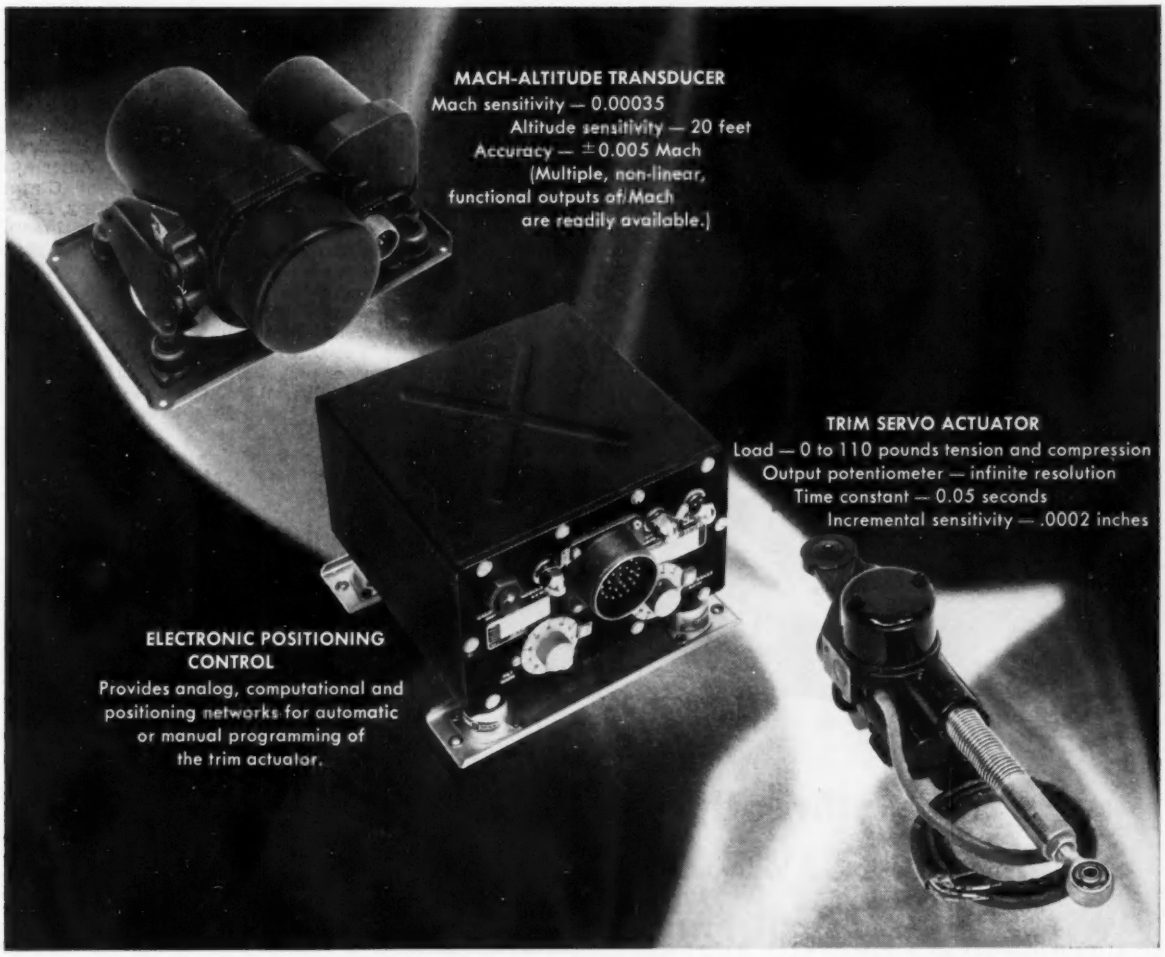
Carbide tipped hobs have been tried for high speed gear cutting, but most machines are not fast enough for carbide application and the tipped hobs are expensive. It has been suggested that when faster, more rugged machines are available, more work can be done with 18-4-1 high-speed tool steel, using increased feeds and speeds, than with carbide tipped tools. Production can be increased by substituting double-thread or triple-thread hobs even though cutting speeds are lowered.

Users are reporting better tool life on gears made from "leaded 8620" steel and alloy steels with 0.04 to 0.06% sulfur, and the gears have proven successful. No highly stressed gears are being made from higher sulfur (0.08 to 0.13%) steels such as SAE 1117 or SAE 1118.

There are two methods recommended for checking gears. In one method, the individual errors in profile, spacing, runout, and lead are inspected; in the other, all these errors are inspected in combination, using a master gear in tight mesh with the work gear on a variable center-distance fixture. Check for the final hardness of carburized and hardened gears can be done with a Rockwell tester, or file, or a combination of both. The important thing is to interpret the file test correctly and it is also important to use a file of the same hardness as the gear being tested.

Warpage or excessive distortion of gears due to heat-treatment cannot be wholly eliminated but may be reduced to a minimum by (1) quenching in hot oil or hot salt (marquenching), (2) die or press quenching, and (3) use of soluble oil-water quench media. Another method is to harden the part selectively by induction or flame heating so as to maintain a soft, machinable material in the area requiring close size tolerance.

(This article is based on the secretary's report of the Panel on Essential Factors in Manufacturing Gears and Heat-Treating Techniques, held as part of the SAE Golden Anniversary Tractor Meeting and Production Forum, Milwaukee, Sept. 12, 1955. Members of the Panel were: Leader: B. W. Keese, Wisconsin Axle Div., Rockwell Spring and Axle Co.; Secretary: E. T. Champ-


MACH-ALTITUDE TRANSDUCER
Mach sensitivity — 0.00035
Altitude sensitivity — 20 feet
Accuracy — ±0.005 Mach
(Multiple, non-linear, functional outputs of Mach are readily available.)
TRIM SERVO ACTUATOR
Load — 0 to 110 pounds tension and compression
Output potentiometer — infinite resolution
Time constant — 0.05 seconds
Incremental sensitivity — .0002 inches
ELECTRONIC POSITIONING CONTROL
Provides analog, computational and positioning networks for automatic or manual programming of the trim actuator.

Proved air data system

AiResearch solves stick-force reversal on latest high-speed aircraft

There's no secret to the development of a fine aircraft air data system. Required are superior components, compatible and reliable, that produce the desired stimulus-response pattern with minimum weight and size and maximum efficiency.

The simple elevator trim servo system illustrated is only one of many integrated systems produced by AiResearch to meet customer requirements. Thousands of AiResearch transducers and actuators of the highest sensitivity and performance are now in service. New ones to even more exacting requirements are constantly being developed.

A few of the fields in which we have extensive experience are temperature and flight controls, instrumentation, air data, ballistics computations and positioning and sensing systems. Let an AiResearch engineering team study your problem and formulate a solution.

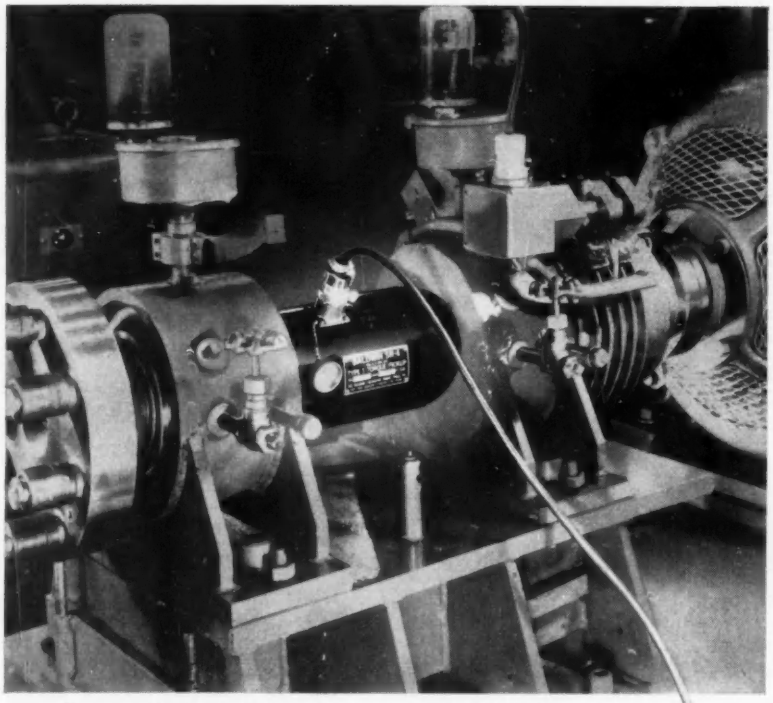
Qualified engineers are needed now. Write for information.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Designers and manufacturers of aircraft systems and components: REFRIGERATION SYSTEMS • PNEUMATIC VALVES AND CONTROLS • TEMPERATURE CONTROLS CABIN AIR COMPRESSORS • TURBINE MOTORS • GAS TURBINE ENGINES • CABIN PRESSURE CONTROLS • HEAT TRANSFER EQUIPMENT • ELECTRO-MECHANICAL EQUIPMENT • ELECTRONIC COMPUTERS AND CONTROLS



Test stand with Baldwin SR-4 torque pick-up for production testing of pumps

read torque directly, accurately to ±¼% with SR-4® torquemeters

The Baldwin SR-4 torquemeter consists of a strain gage type pick-up and companion instrumentation. Shaft torque is read directly in inch-pounds—eliminating complicated equipment involved in measurement of reaction torque.

The Baldwin SR-4 torquemeter is more accurate, too: guaranteed to ±¼% of full range in either direction from 0 to 100% of capacity. For your copy of our bulletin on torquemeters, write Dept. 2656, Electronics & Instrumentation Division, BLH Corporation, Waltham, Massachusetts.

BALDWIN BLH LIMA-HAMILTON

ELECTRONICS & INSTRUMENTATION DIVISION
BALDWIN-LIMA-HAMILTON
DIVISIONS: Austin-Western • Eddystone • Lima • Hamilton • Loewy-Hydropress • Madsen • Electronics & Instrumentation • Pelton • Standard Steel Works

lin, Allis-Chalmers Mfg. Co.; Members: Gear Section—K. C. Adams, Allis-Chalmers Mfg. Co.; A. S. Black, Fellows Gear Shaper Co.; Fred Bohle, Illinois Tool Works; M. L. Fallon, Gleason Works; L. H. Seyefer, International Harvester Co.; Charles Staub, Michigan Tool Co.; J. C. Straub, American Wheelabrator and Equipment Corp.; Heat-Treat Section—M. L. Frey, Allis-Chalmers Mfg. Co.; T. A. Frischman, Eaton Mfg. Co.; N. O. Kates, Lindberg Steel Treating Co.; L. W. Steege, John Deere Waterloo Tractor Works; L. E. Webb, Clark Equipment Co.; D. J. Wright, Caterpillar Tractor Co. The report is available together with six other panel reports as SP-112 from the SAE Special Publications Dept. Price: $1.50 to members; $3.00 to nonmembers.)

Shell-Molded Castings Are Smooth and Accurate

Based on paper by

R. G. MC CULLUM
University of Cincinnati

GREATER smoothness and accuracy are among the advantages claimed for castings made by shell molding. They also have fewer blow holes and less porosity.

The plate-mounted pattern of the part to be molded is heated to 400–500 F and then covered with a mixture of sand and a special resin. The heat from the pattern melts the resin, forming a shell ¼–⅜-in. thick. Next, the pattern with the soft shell is baked at 800 F, producing a hard, firm shell. This half of the shell is removed from the pattern and the other half made by inverting the pattern and repeating the process. The two halves are then glued together and the mold poured. (Paper "Shell Molding" was presented at the Cincinnati Section meeting. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Tubeless Tires Reduce Truck Weight

Based on paper by

L. L. BALDWIN
The Firestone Tire & Rubber Co.

IN addition to blowout and puncture protection, cooler running, and greater safety, tubeless truck tires offer the definite advantage of weight saving.

Replacing a pair of conventional 10.00–20 tires on demountable rims

Aetna

America's No. 1 Producer of Clutch Release Bearings

For more than a third of a century Aetna Clutch Release Bearings have held recognized leadership in design, performance and dependability.

In terms of testimony, over 68,000,000 Aetna Clutch Release Bearings have been produced to satisfy the year-after-year demand of more than 50% of America's major producers of on-and-off-the-road mobile vehicles.

Research, a continuing Aetna program, has contributed more basic improvements, more feature "firsts" in Clutch Release Bearings than any other manufacturer.

Service records and laboratory breakdown tests (up to 1,500,000 de-clutchings) repeatedly prove the unmatched superiority of Aetna Clutch Release Bearings—in life-expectancy, lubricant retention and smooth, silent operating characteristics.

Take time—early in the planning stage, before "freezing" your designs—to test and compare world famous Aetna Clutch Release Bearings. Samples, quotations and complete engineering data are yours for the asking.

Aetna 1908 40 YEARS 1948 FIGHTING FRICTION

AETNA BALL AND ROLLER BEARING COMPANY

Division of Parkersburg-Aetna Corporation

4602 SCHUBERT AVENUE • CHICAGO 39, ILLINOIS

In Detroit — Sam T. Keller, 1212 Fisher Building

Manufacturers of: Standard and Special Ball Thrust Bearings • Angular Contact Ball Bearings • Radial Ball Bearing Mounted Units • Special Roller Bearings • Ball Retainers • Hardened and Ground Washers • Sleeves • Bushings • Miscellaneous Parts

with 11–22.5 tubeless tires on demountable drop center rims gives a weight saving of approximately 121.2 lb per axle. If the replacement is made on disc wheels, the saving aggregates 162 lb per axle.

Tubeless tires differ most radically from the conventional in the bead area. Due to the tight 15-deg wedge fit of the tire on the rim, the bead area is now located in the natural position, in the circle of the structure. The new bead is made of more flexible and pliable material and so is the tie-in of plies around and above the bead area groups. In the old style tire, high flanges supported most of the load; with the tubeless tire the load is supported on the base of the bead—the 15-deg taper. The low flange serves as a stop and centering device, reducing any lever action to a minimum. The air seal is under the bead on the 15-deg taper.

Chafers in conventional tires are mainly square woven cotton fabric. Tubeless tires require a different material or different treatment because air seepage or wicking cannot be permitted. The innerliner which seals the air inside is cured to the tire as an integral part.

Tubeless tires are not interchangeable with conventional types on the same rim; hence size markings are different. Thus, a 10.00-20 on its recommended rim measures the same cross-section and overall diameter as the 11–22.5 tubeless on its recommended rim. In corresponding manner, other sizes of conventional tires are replaced by the tubeless. In respects other than those mentioned, the tubeless and conventional are essentially the same. (Paper "Tire Design—Present and Future" was presented at SAE Golden Anniversary Transportation Meeting, St. Louis, Nov. 2, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

NEW IMPROVED
ELECTRONIC TACHOMETER for
EXTREME ACCURACY

Plus or Minus 1 RPM at Speeds from 10 to 50,000 RPM

No other tachometer or revolution counter is more accurate — more dependable. Revolutions are converted to electrical pulses by the tachometer generator. The Electronic Tachometer counts them accurately for precisely one second and displays the count directly as *revolutions per minute.*

DESIGN EMPHASIS WAS PLACED TO GIVE YOU THESE OUTSTANDING BENEFITS:

★ **EXTREME PRECISION** — Oven-controlled crystal is accurate to 1 part in 1,000,000.

★ **RELIABILITY** — Circuits designed for *continuous service.* Number of vacuum tubes kept to a minimum.

★ **EASY-TO-READ** — Brilliant glow-spots can be read in brightly lighted rooms. Display time is adjustable from .5 to 10 seconds.

★ **SELF-CHECKING** — Frequency Standard has built-in feature to let operator check accuracy of instrument at any time.

★ **MAINTENANCE** — Package-type plug-in construction simplifies servicing.

Write today for complete details. Ask for Bulletin #240.

THE Standard ELECTRIC TIME COMPANY
87 Logan Street • Springfield 2, Massachusetts

New Problems Arise In Process Control

Based on report by

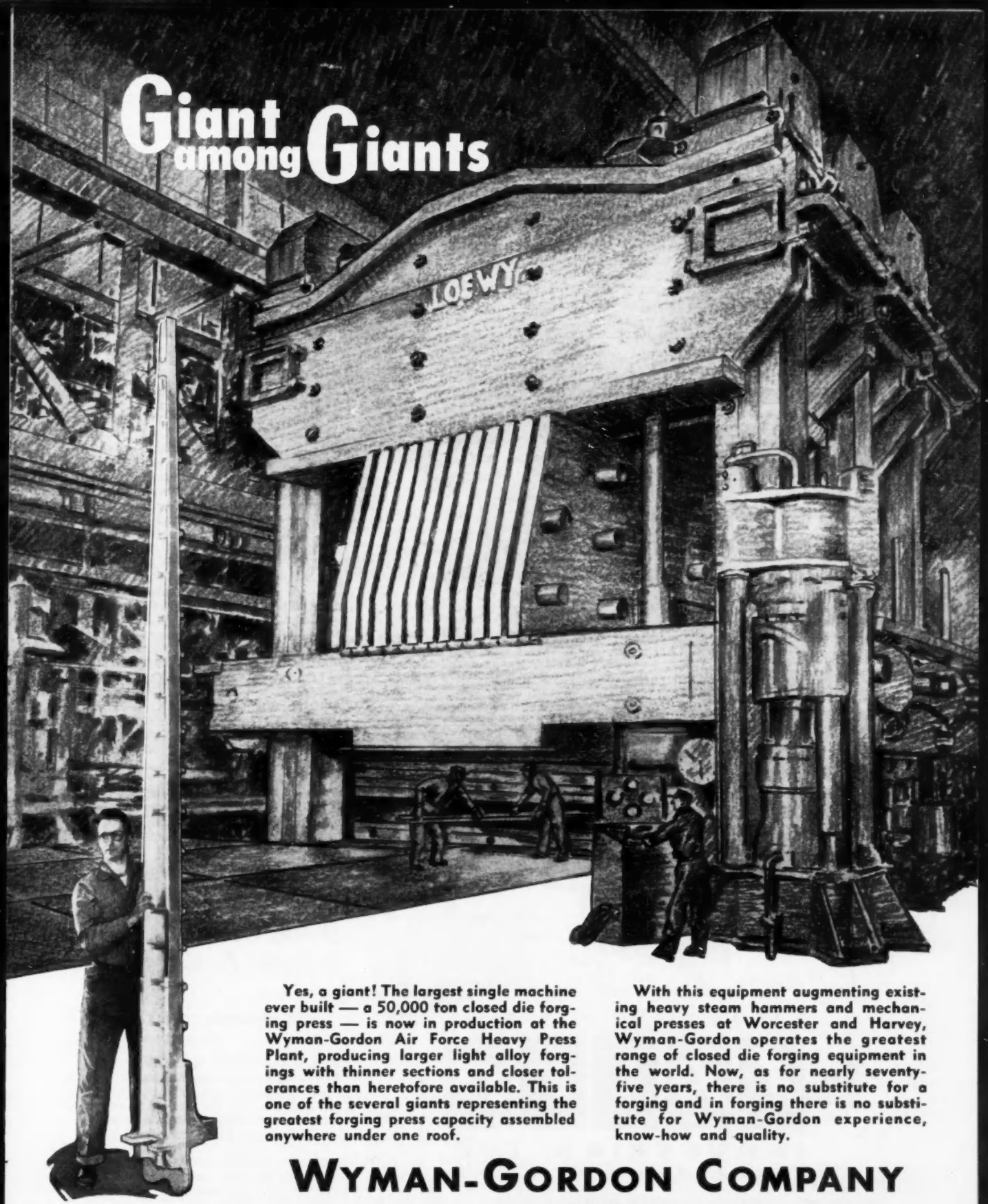
D. F. HAYS
North American Aviation, Inc.

INTRODUCTION of new materials and processes, and a greater use of subcontracting by aircraft prime contractors have focused attention on process control problems whose solution must come from improved specifications, education, and communication.

When the quality of the finished product is partially or wholly non-inspectable except by destructive methods, control is developed with the process since the quality of the end product must be built in. The degree of control required is a function of the complexity of the process (the number of variables), our knowledge of the effect of the variables on the quality of the end product, and design requirements.

Attempts to use facilities which cannot be controlled more closely than the specification limits may mean a continuous maintenance problem to keep them operating within limits. If the maintenance is inadequate, the process control will fail. In many cases, the processes about which the least is known have the closest control and require the most extensive investigation to permit a deviation.

No clear cut area exists between an inspectable and uninspectable process. Operators need training about in pro-



Yes, a giant! The largest single machine ever built — a 50,000 ton closed die forging press — is now in production at the Wyman-Gordon Air Force Heavy Press Plant, producing larger light alloy forgings with thinner sections and closer tolerances than heretofore available. This is one of the several giants representing the greatest forging press capacity assembled anywhere under one roof.

With this equipment augmenting existing heavy steam hammers and mechanical presses at Worcester and Harvey, Wyman-Gordon operates the greatest range of closed die forging equipment in the world. Now, as for nearly seventy-five years, there is no substitute for a forging and in forging there is no substitute for Wyman-Gordon experience, know-how and quality.

WYMAN-GORDON COMPANY

Established 1883

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

WORCESTER 1, MASSACHUSETTS

HARVEY, ILLINOIS DETROIT, MICHIGAN

portion to the complexity of a process and in inverse proportion to the degree to which quality can be determined by final inspection. A process control worker, particularly one working in another company, must be skilled in human relations and communications.

A subcontractor can run into processing difficulties in either of two ways: (1) lack of consistency in the various divisions of a single prime contractor, or (2) conflict among several prime contractors regarding requirements covering similar parts or materials. To overcome these difficulties the following recommendations are made:

1. Use standard process specifications such as the SAE Aeronautical Material Specifications (AMS).

2. Coordinate the activities of the technical people who issue or apply specifications so that particular processes will have the same fundamental philosophy.

3. Avoid the writing of company specifications that restrict a fabricator to a particular proprietary product or technique.

4. Use specifications for end product requirements and place more responsibility for getting results on the subcontractor. Use fewer in-process specifications which tie the fabricator's hands.

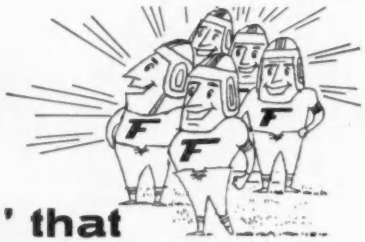
5. Select subcontractors who are equipped for quality work, experienced in the type of work wanted, and who do not need so much in-process hand holding.

6. Give the subcontractor the same leeway you would give your own people in following process specifications.

Serious troubles can arise from a lack of understanding or disregard of the characteristics of new materials as they apply to all phases of a business—engineering design, tooling, fabrication, assembly, processing, and inspection. But new materials do bring definite advantages and they cannot be ignored. More systematic means must be devised for study, evaluation, introduction, and control of these materials, both in engineering and manufacturing, to hold the costs involved within reasonable bounds.

(This article is based on the secretary's report of Forum on Process Control held at SAE Golden Anniversary Aeronautic Meeting and Production Forum, Los Angeles, Oct. 11, 1955. Members of the Panel were: Leader: B. R. Swarts, Convair Division, General Dynamics Corp.; Co-leader: H. B. Sipple, Lockheed Aircraft Corp.; Secretary: D. F. Hays, North American Aviation, Inc.; Members: A. A. Bibee, Douglas Aircraft Co., Inc.; H. Brown, Solar Aircraft Co.; H. D. Childers, Northrop Aircraft, Inc.; L. H. Ferrish, Lockheed Aircraft Corp.; F. H. Matthews, Boeing Airplane Co.; V. S. Sorenson, Northrop Aircraft, Inc. The report is available together with other panel reports as SP-313 from the Special Publications Department. Price: $2.00 to members; $4.00 to nonmembers.)

FASCO



The "Extras" that became "Regulars"

On America's Leading Cars and Trucks

- AUTOMATIC RESET CIRCUIT BREAKERS
- DIRECTIONAL SIGNAL FLASHERS
- HYDRAULIC STOPLIGHT SWITCHES
- LOW-PRESSURE INDICATING SWITCH
- SERIES "400" PRESSURE SWITCHES
- HEADLAMP SWITCH

Time was, when Fasco automotive components such as these were considered only as "extras." But they served their purpose so well and contributed so much to over-all performance and customer satisfaction—that one by one, they have been adopted as standard equipment by America's leading manufacturers of cars and trucks . . . a fine tribute to Fasco engineering skill and product dependability.

In the future, as today, Fasco will be ready with "look-ahead" designs to meet the requirements of the automotive industry . . . proof again that it always pays to Consult Fasco First!

NEW!
FASCO AUTOMATIC RESET MOTOR PROTECTOR
NEW! FASCO LOW-PRESSURE OIL INDICATING SWITCH
FASCO SERIES "400" PRESSURE SWITCH
FASCO HYDRAULIC STOPLIGHT SWITCH
NEW! FASCO HEADLAMP SWITCH with Integral Circuit Breakers

AUTOMOTIVE DIVISION

FASCO INDUSTRIES, INC.

ROCHESTER 2, NEW YORK

DETROIT OFFICE—12737 PURITAN—PHONE: UN 17476

Styling Trucks Multiplies Problems

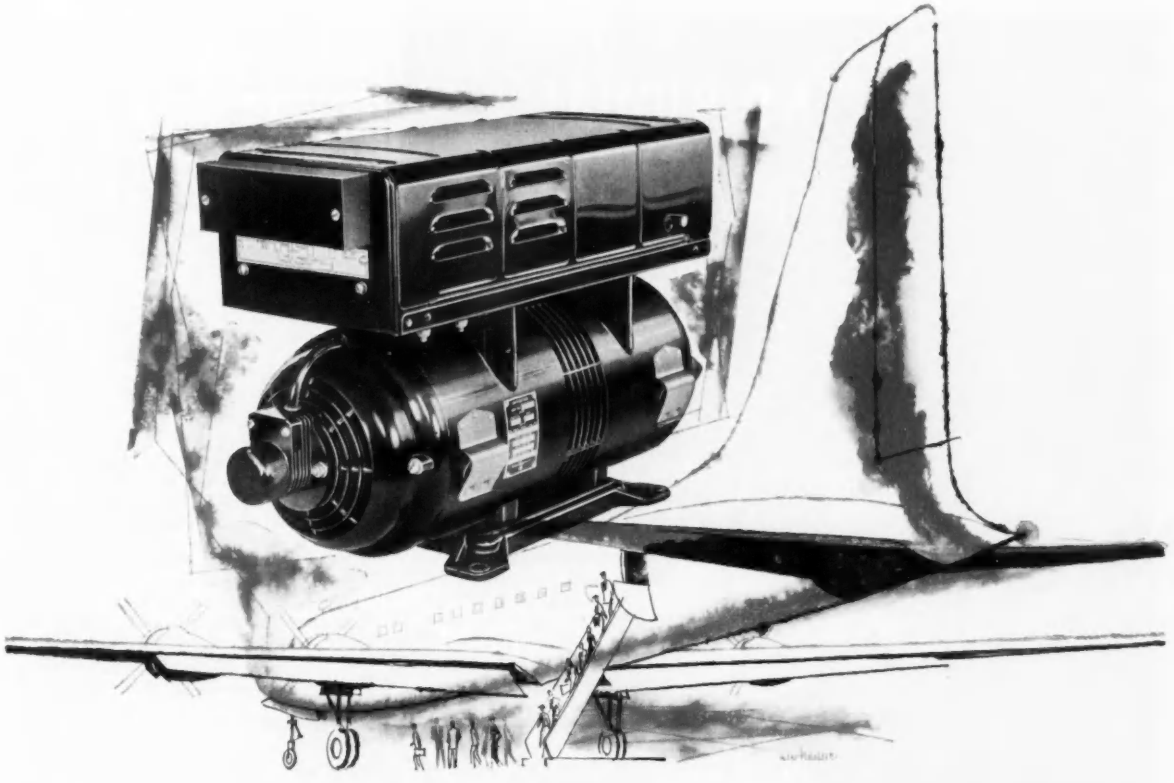
Based on paper by

THEODORE ORNAS

International Harvester Co.

THE styling of trucks has become increasingly important, and more difficult. Although trucks are bought for payload use, it is thought necessary to make frequent changes in the appearance of cab and front-end sheet metal for sales appeal. The result is that revised engineering, tooling, and manufacturing of these parts adds to the other cost of the product.

The fashionable low silhouette is



3000-VA INVERTER...SIMPLIFIES A-C POWER BOOST FOR AIRLINES!

To fulfill the requirements of commercial airlines for increased electric system capacity, a necessity when installing radar and other special a-c devices, Jack & Heintz has perfected a 3000-volt-ampere inverter, the F45-10.

The 3000-va inverter represents a 20% power boost over inverters now on the market. Through careful design, this 20% increase in output has been accomplished with less than a 2% increase in total weight and with no increase in space requirements.

To simplify maintenance and parts stocking problems, 90% of the parts used in the unit are completely interchangeable with the popular 2500 va—J & H model F45-5.

The new model F45-10 is available, immediately, for replacement installations. Or, existing 2500-va F45-5's may be quickly and easily converted for 3000-va output with a conversion kit. In either case, the additional 500-va increase in output is obtained with a total weight penalty of only one-half pound.

Send for product data bulletin No. 1344 for detailed information on this important Jack & Heintz first. Write Jack & Heintz, Inc., 17638 Broadway, Cleveland 1, Ohio. Export Department: 13 East 40th Street, New York 16, New York.

F45-10 INVERTER
Operating Characteristics

	Single Phase *	Three Phase
Output Rating		
Full Load	3000 va	3000 va
Rated a-c Voltage	115	115
Line Amps	24	15
Nominal Frequency (cps)	400	400
Power Factor	90% Lag to 95% Lead	
Rated Input Voltage — d-c	27½	27½
Input Amperes — d-c (at Rated Voltage)		
No Load	44	44
Full Load	185	185
Over-all Dimensions—Inches		
Length	17 13/16	
Width	7 1/16	
Height	11 13/16	
Weight—Pounds	54	

* Load across terminals BA

JACK & HEINTZ ELECTRIC AIRCRAFT EQUIPMENT

INDIVIDUAL
PROFESSIONAL
DEVELOPMENT
for engineers
in
supersonic propulsion
Marquardt, the leader in supersonic propulsion, has inaugurated a program of Individual Professional Development for its engineers. You can help us maintain this leadership for the future of supersonic propulsion.
I.P.D. gives our engineers a chance to advance to their maximum potential in their present fields... and those beyond... in a climate of continuing professional growth from in-plant courses and more than fifty current courses in Southern California's leading universities. New courses are constantly being added.
I.P.D. differs in its concept and objectives from ordinary company training programs in that it gives each engineer an opportunity to grow and plan his development toward his own goal and at his own pace rather than having to follow a rigid predetermined pattern.
I.P.D. is a part of an overall expansion program which anticipates a two-fold increase in personnel during the current year. This increase represents many additional engineering opportunities. You can become a leader in supersonic propulsion. Write for details.
marquardt AIRCRAFT CO.
Attention: Professional Personnel
Industrial Relations Department • 16555 Saticoy St., Van Nuys, California
MARQUARDT BUILDS THE POWERPLANT FOR THE BOMARC IM-99 INTERCEPTOR MISSILE

hard to get in a load-carrying vehicle. Styling is affected in many ways by federal and state highway laws. Cab interchangeability is greatly influenced by styling because what looks well on one size of truck may appear distorted on another. In all cases consideration must be given to accessibility, proper cooling, and visibility, for correct functioning comes first.

The styling of cab interiors in conjunction with functional engineering can produce interesting, though perhaps intangible results. It is a known fact that proper design and color harmony can reduce physical and mental fatigue, although it would be difficult to graph the increase in comfort due to well integrated interiors. By today's styling standards, any vehicle priced at over $4000 should have the form and color of its interior well integrated, but most heavy-duty trucks show a sad lack of such development.

An organization of shapes suggesting jet airplanes plus superfluous chrome gimmicks seems a dishonest approach to heavy-duty truck requirements. Styling should develop a character of design compatible with the product's function. The design will be more successful when it expresses a feeling of ruggedness and durability.

(Paper "Motor Trucks—Heavy Duty Plus Beauty" was presented at SAE Passenger Car, Body, and Materials Meeting, Detroit, March 7, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

New Techniques Advance Welding Art

CLIFFORD LaDEW
Cutler-Hammer, Inc.

RECENT developments with carbon dioxide as a shielding gas point to the successful use of the consumable electrode welding process for the welding of mild steel. Use of carbon dioxide promises to reduce the cost of gas shielding to 1/20 of that incurred with mixtures of argon, helium, and oxygen. At the same time, advances in the technique of contact, or iron-powder, electrode welding create possibilities for substantial reduction of welding costs on many applications.

In the new gas-shielding method, the current density employed on the electrode ranges from 40,000 to 400,000 amp per sq in., or 10 to 50 times the amount normally used for stick welding. This high density requires the use of very small electrodes to prevent the current from becoming unmanageable. Their consumption rate is usually several hundred inches per minute and when the wire is feeding at this high rate it must be consumed at the same

SKF® Has Them All

If you want to be *sure* you are putting the right bearing in the right place in your product, check with SKF—the *one* bearing manufacturer selling all four major types of anti-friction bearings. From this single source, you quickly and easily get unbiased advice based on the broadest experience in the anti-friction field. **SKF INDUSTRIES, INC.**, PHILADELPHIA 32, PA.

7710

SKF

Ball Bearings Cylindrical Roller Bearings
Spherical Roller Bearings Tyson Tapered Roller Bearings

rate to prevent stubbing of burn backs. Electrode consumption rate depends almost entirely upon current density on the electrode. Thus, the wire travel speed produced by the wire driving mechanism predetermines the current necessary for smooth operation.

The carbon dioxide gas must be dry, and to this end a welding grade with very low dew point is available. In addition, a very short arc length must be used. The end of the electrode should be at the surface of the plate or even below it. Then the weld spatter is deposited in the weld puddle. The short arc also produces very deep penetration to the weld bead. Weld spatter is reduced further by welding forehand and increasing travel speed.

The American contact, or iron-powder, electrode is suitable for welding with the drag technique, but few have the automatic striking and restriking ability of the European version.

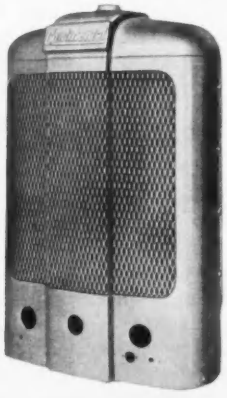
The principal function of the iron powder added to the coating is to permit the use of higher welding amperages and to enable the designer to increase the built-in arc voltage of the electrodes, both of which increase the weld metal deposition rate. The powder, not being a part of the welding circuit except in the immediate vicinity of the arc, cools the weld metal as it melts in the molten puddle, thus preventing its overheating and attendant difficulties. The large quantities of iron powder enable the coating thickness to be increased. This alters its refractory crucible depth, increases the arc voltage, and changes the character of metal transfer across the arc progressively from a globular to spray type. The increase in coating thickness also enables the electrode to be used with the drag technique without the danger of sticking as with the conventional type.

The weld nugget of contact electrodes is derived from the electrode and the base metal, whereas the weld nugget of most conventional electrodes comes almost entirely from the core wire. The amount of metallics introduced from the coating to supplement the metal deposited from the core may vary from 5 to 100% by weight of that available from the core. The high percentage of metallic additives to the coating alters the arc characteristics and the pattern of base metal penetration.

Four types of iron powder electrodes are available commercially. An all-position titanium type, a titanium type

YA® Radiators

TERMINAL ISLAND in Los Angeles Harbor has been sinking at an alarming rate, and it is estimated that by 1965 the entire island will have slipped beneath the surface. To delay this sinking, and to protect huge industrial plant investments on the island, giant pumps have been installed within the dikes surrounding the plant to take care of the seepage. And these engine driven pumps, on which so much depends, are equipped with Yates-American Heavy Duty Radiators. If you are confronted with a similar problem, call on Yates-American to come up with the correct answer in dependable radiator equipment.



California Representative: E. E. Richter & Son, Emeryville, California

YA® Yates-American
HEAT TRANSFER PRODUCTS DIVISION
BELOIT, WISCONSIN
BRANCH OFFICES
Chicago, Illinois; High Point, North Carolina;
Memphis, Tennessee; Portland, Oregon

Panel on Welding . . .

Panel Leader:

Chauncy Hart
The Heil Co.

Panel Secretary:

Clifford LaDew
Cutler-Hammer, Inc.

Panel Members:

Harold Baumler
Pressed Steel Tank Co.

C. H. Burgston
Deere & Co.

D. C. Smith
Harnischfeger Corp.

J. Turk
Hotpoint, Inc.

R. W. Tuthill
General Electric Co.

George Zippay
Deere & Co.

NOW! FOR THE FIRST TIME

DIRECT WRITING CONVENIENCE WITH PHOTOGRAPHIC ADVANTAGES!

Introducing **Century ELECTROGRAPH MODEL 420**

ELECTROPHOTOGRAPHIC RECORDING OSCILLOGRAPH

You Asked For This!

ONLY THE REVOLUTIONARY CENTURY ELECTROGRAPH OFFERS THESE FEATURES

- ***Permanent instantaneous oscillograms***
- ***Eliminates need for messy liquid chemicals***
- ***No darkroom required***
- ***Automatic continuous dry processing***
- ***View oscillogram while recording***
- ***Utilizes sensitive light-beam galvanometers***
- ***Up to 24 traces on eight inch paper***
- ***Traces can overlap***
- ***Precision timing lines***
- ***Low power consumption***

Century's engineers are the first to accomplish the long dreamed-for wedding of photographic recording and completely automatic dry processing to eliminate the need for costly darkroom facilities and liquid developing, rinsing and fixing.

The greatest advancement in the technique of multi-channel oscillograph recording in over 20 years, the CENTURY ELECTROGRAPH is essentially a direct-writing recording oscillograph utilizing the RADICALLY new technique of Electrophotography combined with light-beam galvanometers.

NOW investigate CENTURY ELECTROGRAPH—the most modern approach to simplified oscillographic recording — when planning your instrumentation program whether for research, engineering, test, quality control, process control, or any other analog recording requirement.

COSTS NO MORE THAN OLD-FASHIONED METHODS

Century

Century Electronics & Instruments, Inc.

1333 NO. UTICA, TULSA, OKAHOMA

For further information, call on our nearest representative:

EXPORT OFFICE: 149 BROADWAY, NEW YORK CITY — TEL.: BARCLAY 7-0562

PHILA.-WASH. AREA	N.Y.-NEW ENGLAND AREA	MIDWEST AREA	TEXAS-N. M. AREA	ARIZONA AREA	SO. CALIF. AREA	NO. CALIFORNIA
4447 N. BODINE ST.	29-46 NORTHERN BLVD.	363 W. FIRST ST.	5526 DYER ST.	3886 BAKER PL.	40 SO. LOS ROBLES	2015 EL CAMINO REAL
PHILADELPHIA 40, PA.	LONG ISLAND CITY 1, N. Y.	DAYTON 2, OHIO	DALLAS, TEXAS	TUCSON, ARIZONA	PASADENA 1, CAL.	REDWOOD CITY
TEL.: MICHIGAN 4-1822	TEL.: STILLWELL 4-7120	TEL.: FULTON 9292	TEL.: EMERSON 6716	TEL.: 7-1501	TEL.: RYAN 1-9663	TEL.: EMERSON 6-8214

limited to flat and horizontal fillet welds, an iron oxide type for flat and horizontal fillet welds, and a low hydrogen type. The second type is the most popular, but the iron oxide type is gaining in favor.

(This article is based on the secretary's report of Panel on The Future of Welding held as part of the Production Forum at the SAE Golden Anniversary Tractor Meeting and Production Forum, Milwaukee, Sept. 12, 1955. It is available in full in multilith form together with the reports of the other six panels at this Forum, as SP-312 from SAE Special Publications Department. Price: $1.50 to members, $3.00 to nonmembers.)

Synthetics Launch New Era in Textiles

Based on paper by

RICHARD T. CHATHAM, JR.
Chatham Mfg. Co.

THERE'S more to textile designing than the creation of a pattern. The designer must take into consideration: weight, tensile strength, shrinkage, stretch, resistance to abrasion, dye and light stability, soil resistance, and water repellency. He must figure how to attain the best possible compromise since all textiles must be constructed to meet a price.

The designer knows, for example, that nylon filament will give a fabric with highest breaking strength in warp direction. However, the price range of the finished textile may be so low that use of nylon for the warp will leave so little money for the filling as to require the most inexpensive type of yarn, which in many cases will not meet the customer's requirements for breaking strength. In such instances, the designer is forced to use a different type of warp yarn so that stronger fibers can be used in the filling and thus create a more balanced fabric.

Automotive fabrics have progressed from mohair plush to woolens, to patterns, to synthetics. These man-made fibers are now widely used in the filaments of bodycloths, but there still remains room for development. It is possible that synthetics and natural fibers will be used in combination to produce an ideal bodycloth, better engineered for its end use. At the moment, textile designers need to be taken more into the car manufacturer's confidence and to be treated as partners rather than as suppliers. The designer can do a better job if he knows the overall objectives. (Paper "Your Living Room on Wheels" was presented at SAE Passenger Car, Body, and Materials Meeting, Detroit, March 6, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

DOLE DV
THERMOSTATS
the accurate temperature control for modern engines

Highly developed for positive operation against the increased pump pressures in sealed cooling systems, and with all types of antifreeze solutions. Helps maintain best engine performance —speeds warm-up—saves gasoline and oil—reduces wear. Gets more heat from the car heater.

Now standard equipment on thirty-seven (37) leading makes of cars, trucks, tractors, commercial vehicles, industrial and marine engines.

Literature sent on request—please use your letterhead.

Control with Dole DOLE
TRADE MARK
THE DOLE VALVE COMPANY
1901 Carroll Ave., Chicago 12, Ill.
Detroit • Los Angeles • Philadelphia

1956 Control with DOLE 1956 50th Anniversary

Tufted Carpet Boon to Car Makers

Based on paper by

JOHN H. COX
Mohawk Carpet Mills, Inc.

TUFTED carpet, a relative newcomer to the floor covering field, has been adopted with avidity by car producers because it can be had within two to three weeks of order as contrasted with six to eight weeks for the woven product, thus making production schedules more flexible.

The new carpeting is made by a sewing machine technique at about ten times the speed of weaving. It is fabricated in white, then dyed in multiple roll lots which makes possible production for storage against later orders for finishing. It is being made in all cotton, all rayon, and in rayon and nylon blends, as well as in woven wool and wool and rayon. And coupled with spinning systems which produce yarns with striking luster, effects are achieved that hitherto were unobtainable.

(Paper "Tufted Carpet for Auto Use" was presented at SAE Passenger Car,

WANTED! ENGINEERS TO HELP MAKE LONG RANGE MISSILE HISTORY

North American's Missile Projects Offer A New Engineering Adventure

With complete weapons system responsibility for the SM-64 NAVAHO Intercontinental Guided Missile, North American is engaged in one of the most challenging programs yet offered. But every inch of progress is a tough scientific battle. New means are daily being found to solve the complex problems which the development of long range missiles presents in the fields of structures, temperatures and aerodynamics. But most important of all, *men* must be found who thrive on this kind of challenge . . . men who are really excited about this new missile science. Are you one of them?

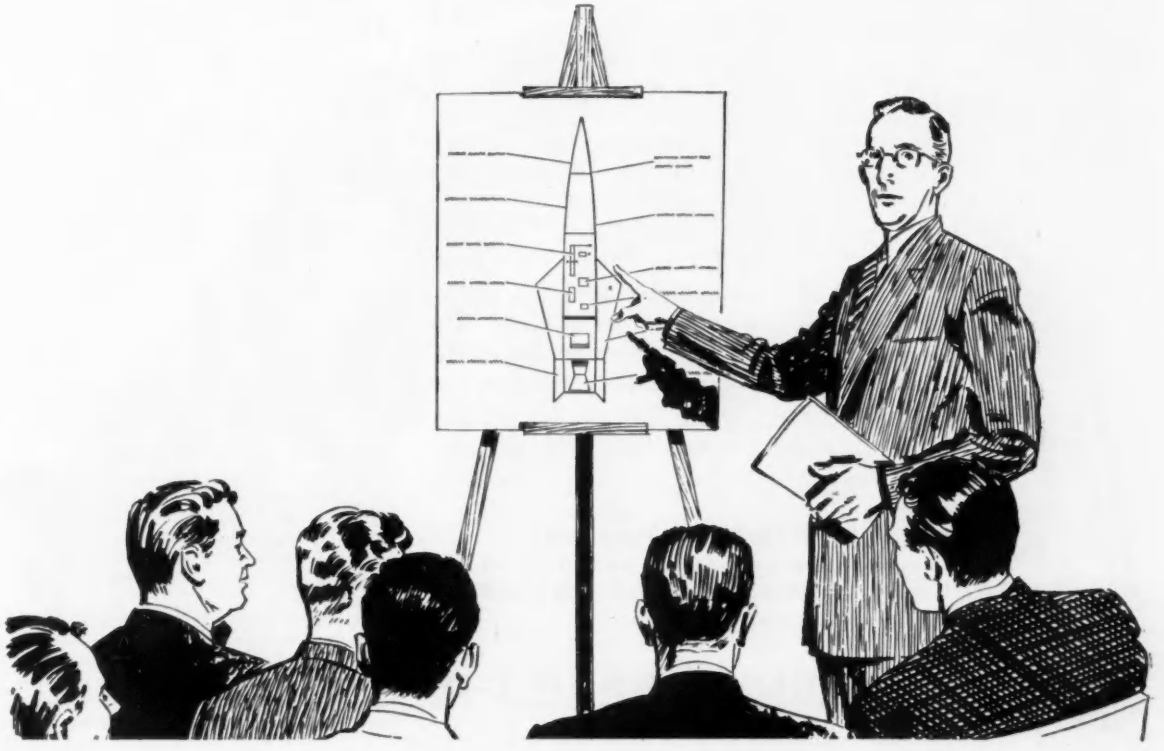
If you qualify in one of the fields we have listed below, chances are you can qualify for this unique expedition into the technology of the future. We would like to tell you about all the physical and professional advantages of a career in North American's Missile Development Engineering.

Please contact us for the full story:

Instrumentation Design, Development & Application **Standards, Drawings Checking, Specifications Writing**
Structures, Stress, Flutter and Aeroelasticity **Component and System Reliability Engineering** **Thermodynamics**
Missile Airframe Design **Hydraulic, Pneumatic & Servo Engineering** **Armament Systems & Components Engineering**
Aerodynamics **Engineering Flight Test** **High Temperature Materials Engineering** **Mechanical & Electrical Design**

Contact: R. L. Cunningham, Missile Engineering Personnel Office
Dept. 91-20 SAE, 12214 Lakewood Boulevard, Downey, Calif.

NORTH AMERICAN AVIATION, INC.



Check the response-to-the-touch. You can actually feel the difference!

That's why the Paragon Drafting Machine noticeably cuts end-of-the-day fatigue . . . saves costly man hours . . . helps raise working standards.

See how easily protractor control ring can be reached—no matter what position your hand is in. Another time saver. Touch that ring with your *little* finger and scales rotate freely. Release pressure and scales automatically lock to nearest 15° position. And intermediate angles are just as easily set!

Top day-to-day performance is guaranteed by unique "open center" design of arms which protects smooth-working factory-set band tension.

A good look at a Paragon and a touch on that control ring is worth 1,000 words! Try it before you buy *any* drafting machine—you can *feel* the difference.

89 YEARS OF LEADERSHIP

In equipment and materials for drafting, surveying, reproduction and optical tooling . . . in slide rules and measuring tapes.

KEUFFEL & ESSER CO.

NEW YORK • HOBOKEN, N. J. • Detroit • Chicago • St. Louis • Dallas • San Francisco • Los Angeles • Seattle • Montreal

Body, and Materials Meeting, Detroit, March 6, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

USAF Gives Turboprops Accelerated Test

Based on paper by

COL. CLAUDE W. SMITH
U. S. Air Force

STUDIES indicating that the turboprop might be the powerplant to give transport aircraft greater performance capabilities have prompted the USAF to give various turboprop engine-propeller combinations accelerated service testing in test bed aircraft. One of these combinations—an Allison YT-56-A3 and Aeroproducts propeller in a Convair 340—has completed 70% of its flying time program, or sufficient to warrant comment on performance.

At the start of the project the operating time limit of the engine was 50 hr. As its reliability became established, its life expectancy was raised to 100, then 150, and finally 200 hr. Premature engine removals are listed below by life expectancy category:

100 Hour Life Expectancy
Rear compressor oil seal failure (3)
Oil leak—diffuser vents (2)
Foreign object damage
Oil contamination—scavenge line broken

150 Hour Life Expectancy
Foreign object damage

200 Hour Life Expectancy
Foreign object damage
Starter disintegration (2)
Internal failure—gearbox
Oil leak—diffuser vents
Vibration

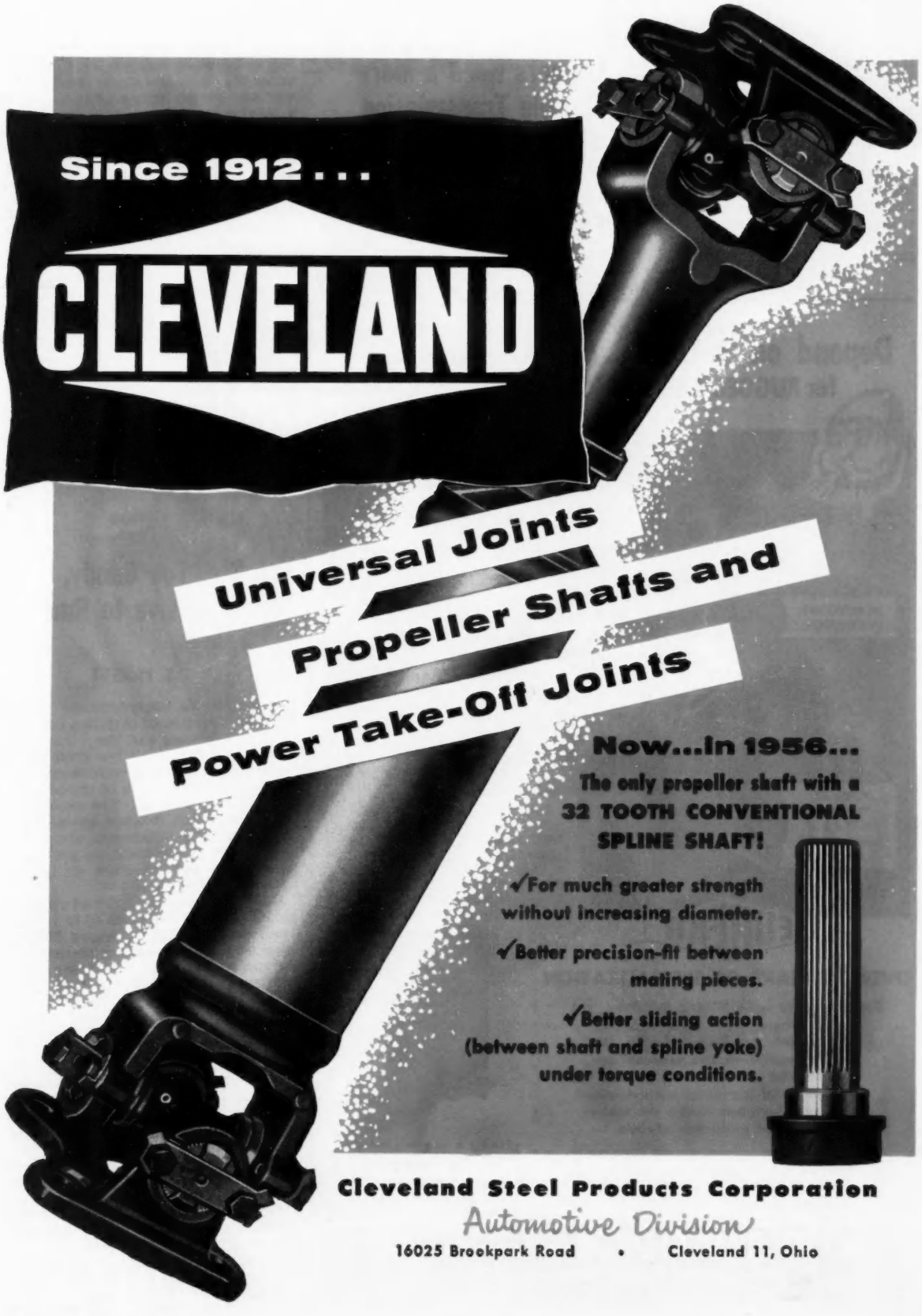
Modification of the air diffuser overcame that oil leak problem. Replacing prototype with production items alleviated oil seal malfunction, as well as the recurring failure of speed-sensing switches. Synthetic rubber diaphragms of the engine bleed valves, which release air upon demand from the fifth to tenth stages of the compressor, had deteriorated under high temperature. This failure was eliminated by using a production piston-type valve.

Turboprop engines require a propeller of much more exact design than do reciprocating engines. Sensitivity to minute acceleration factors and absorption of tremendous horsepower loads are primary requirements. We cannot underestimate the future of the propeller coupled to turbine power. It provides rapid acceleration on take-off and absolute control of the required landing distance through use of positive and immediate reverse braking action. Propeller operating limits were

Since 1912 . . .

CLEVELAND

Universal Joints
Propeller Shafts and
Power Take-Off Joints



Now...In 1956...

The only propeller shaft with a 32 TOOTH CONVENTIONAL SPLINE SHAFT!

✓For much greater strength without increasing diameter.

✓Better precision-fit between mating pieces.

✓Better sliding action (between shaft and spline yoke) under torque conditions.

Cleveland Steel Products Corporation

Automotive Division

16025 Brookpark Road • Cleveland 11, Ohio

revised upward by stages from 150 to 1000 hr. Propeller performance has been highly satisfactory though removals were required by a ruptured pitch lock seal and transfer seal, and contaminated oil. (Paper "Accelerated Service Testing of Turboprop Engines in USAF Test Bed Aircraft" was presented at SAE Annual Meeting, Detroit, Jan. 11, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Loggers Need a More Flexible Transmission

Based on paper by

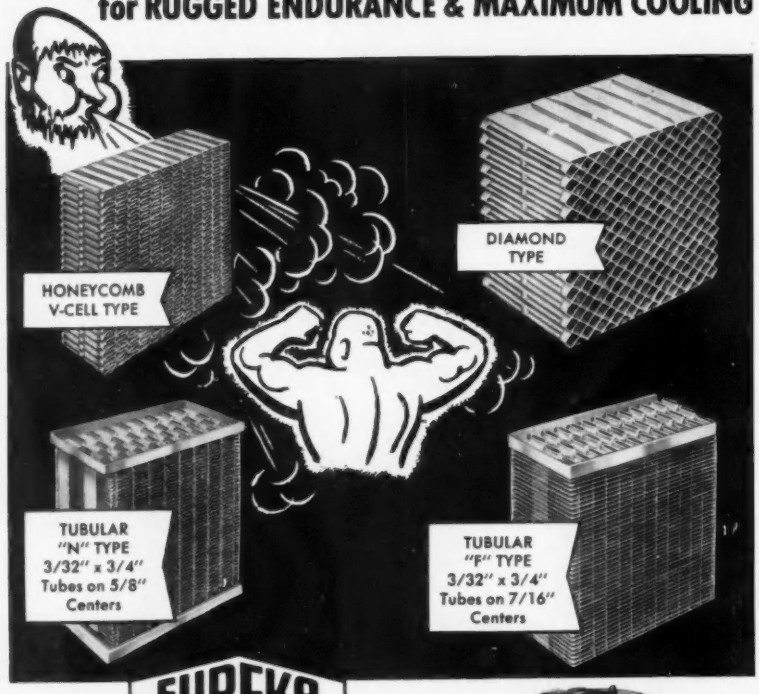
GORDON A. MacGREGOR
MacGregor Triangle Co.

LOGGING usually calls for off-highway and on-highway hauling. Hence truck manufacturers are building units which will stand up better under the stress and strain of off-highway use, yet be light enough to carry a maximum payload on public roads.

Excellent results are being achieved by using aluminum alloys, high-tensile steels, supercharging and turbocharging of engines to get greater horsepower, and new materials in tires. Still lacking, however, is a transmission with sufficient reduction for off-the-road operation, yet with efficient progressive splits for fast highway travel without additional weight. Some work has been done to develop a multi-use transmission, but further development is needed for full solution of the off- and on-highway trucking problem.

(Paper "Use of Heavy Equipment in Logging" was presented at SAE Central Illinois Earthmoving Industry Conference, Peoria, April 4, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Depend on EUREKA RADIATORS
for RUGGED ENDURANCE & MAXIMUM COOLING



EUREKA

OVER 30 YEARS OF SPECIALIZATION

For over 30 years, EUREKA Cores and Radiators have served the automotive industry with utmost dependability. Our facilities, equipment, and personnel are available for your needs. We welcome the opportunity of integrating our specialized skills with your needs to help you achieve a well-planned production schedule.

What are your requirements? We can build Radiators to your order in any type, to any size or shape. Send us your blueprints for prompt quotations!

EUREKA RADIATORS AND CORES
for CARS, TRUCKS, TRACTORS and SPECIAL APPLICATIONS.

AUTO RADIATOR Manufacturing Co.
Guaranteed Radiator Cores Since 1915
2901-17 INDIANA AVE. • CHICAGO 16, ILLINOIS

Too Big, Too Gaudy, Too Expensive to Run

Based on paper by

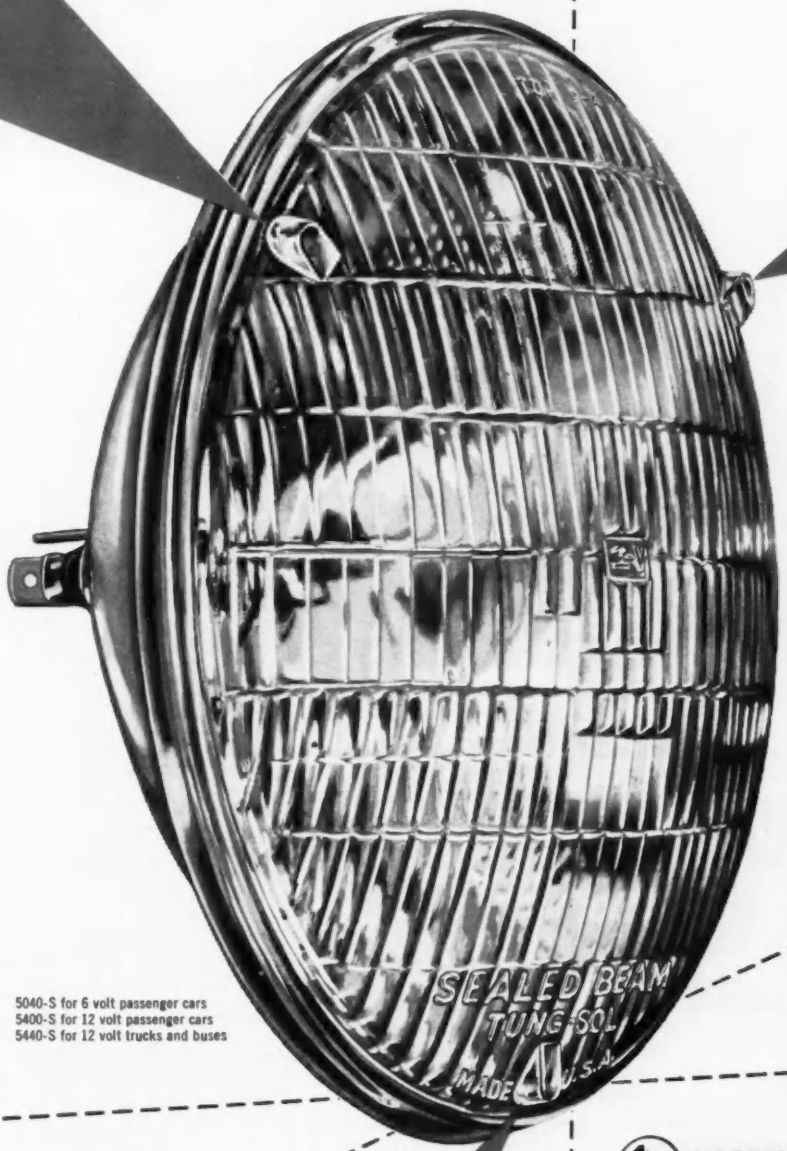
R. J. S. PIGOTT

WE are pushing the automobile too far in the direction of so-called convenience, appearance and size. The simple, single bar bumper has given place to a most distorted, overchromed mess of steel—probably 75 lb of unnecessary and ineffective metal. The decoration is wholly of the jukebox school, both in unnecessary ornaments and color. There may be as much as 300 lb of unnecessary gadgets stuck on in the holy name of styling.

The average car has moved up from 2500 to 3300 lb, and from 40 to 180 hp. The heavy cars have changed little in weight but the horsepower reaches 300. European cars, as a whole, run two-thirds the weight of our cars, have 55% of our horsepower, run with less than two-thirds the gas, and have a top speed 50% higher than our usual speed limit.

Some day we shall have to consider conserving natural resources because they won't last forever at the rate we squander them. We shall arrive finally at the situation Europe has been in for a century. When we are short of materials, then, and then only, will we get really sensible—that is, economical. (Paper "Where Did It Come From" was presented at SAE Pittsburgh Section Meeting, May 18, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

VISION-AID HEADLAMPS



now with

E·Z AIM PLATFORMS

Precision-molded platforms for accurate beam adjustment with all approved aiming devices

5040-S for 6 volt passenger cars
5400-S for 12 volt passenger cars
5440-S for 12 volt trucks and buses

TUNG-SOL®

52 YEARS OF LEADERSHIP IN AUTOMOTIVE LIGHTING

TUNG-SOL ELECTRIC INC., NEWARK 4, N. J.

Sales Offices: Atlanta, Columbus, Culver City, Dallas, Denver, Detroit, Melrose Park (Ill.), Newark, Philadelphia, Seattle, Canada: Montreal.

Miniature Lamps | Sealed Beam Headlamps | Signal Flashers | Radio and TV Tubes | Aluminized Picture Tubes | Special Purpose Tubes | Semiconductors | Color Picture Tubes

B & O Tests Air Filters on Diesels

Based on paper by

PELL KANGAS
Baltimore and Ohio Railroad

TO determine the effect of air filtration on diesel engine wear, the Baltimore and Ohio has undertaken comparative tests of electrostatic, centrifugal, and oil bath filters on diesel engines used on its Wheeling Division, where wear rates are high and engines operate in a circumscribed area. Later, wear of engine parts will be measured and correlated with the findings on filter efficiency.

The method chosen for measuring the dust-collecting ability of a filter, and applied specifically to the electrostatic type, was based on examining a sample of dust collected by impingement on oiled microscope slides that were placed in the air stream both before and after the filter. This method worked best for test positions where the air stream velocity was similar at both locations which was true only for the electrostatic and the 4-in. impingement type panel filter now in use.

The 1×3-in. microscopic slides were permitted to ride for 80 to 300 miles, then carefully removed and protected with cover glass. The slides were then examined under a light microscope with 40X objective and 10X ocular. With this magnification the field formed by the reticule was 250×250 microns in size. It was subdivided into 25-micron squares of which one was divided further into 5-micron squares. This permitted counting particles ranging upward in size from about 1 micron.

The slide was first scanned to note the general character of the particle distribution. The normal method of counting was done by reading the fields along a vertical centerline section of the microscopic slide. Care was taken to get a representative particle count from each slide. The count provided particle size distribution data which permitted studying size selectivity characteristics of the filters. Efficiency was calculated by determining the ratio of the number of particles impinged on the outer and inner slides by number, size, and volume.

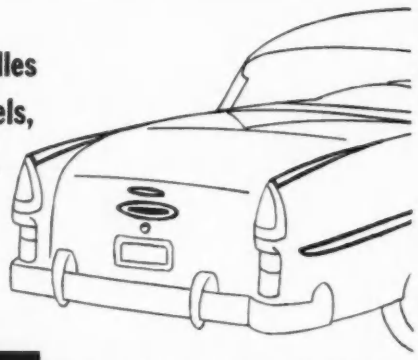
Efficiency by particle count gives equal value or status to all particles ranging in size from 1 to 100 microns. Since the majority of particles are in the 1 to 5 micron range, sizes that have been found to contribute least to wear, particles above 5 microns in size were considered separately in determining a second and probably more valid efficiency figure.

Efficiency by particle size was computed from the particle size distribution figures for the average field. The mean size for each size range was multiplied by the number of particles in that size range. The efficiency thus derived took into consideration the particle diameter. Only the minimum diameter of the particles was considered in these data. Since the size of the particle is related directly to wear factors such as clearance between moving parts and oil film thickness, efficiency by particle size appears to be a more valid figure than that by count alone. This again was computed for particles above 5 microns as well as for those above 1 micron.

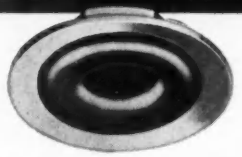
Efficiency by particle volume was computed from the mean sized particle in each size range. This figure tends to give undue emphasis to the few large particles. Other studies have shown the large particles of road dust causing less wear than those in the 20-micron region because of their fragmentation under load. Therefore, efficiency by volume may be considered less useful than the efficiency by size data derived from this test.

The oiled microscope slide method

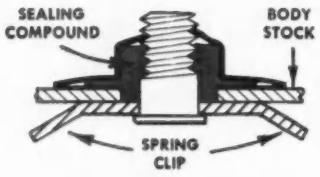
Here's the most effective, low-cost lock nut to
Seal out Water, Dirt and Dust
when fastening
emblems, moldings and handles
on rear deck, quarter panels,
rear fenders, roof, etc.



SEALER TYPE
PALNUT
Trademark®
WASHER LOCK NUTS



PALNUT Sealer-Type fasteners combine the functions of a nut, a lock washer, a flat washer and a sealer washer in a one-piece fastener. Essentially these are PALNUT Washer-Type fasteners with a resilient, clean plastisol compound bonded securely to the washer face. Body enclosures are effectively sealed against water and dust seepage. Significant cost savings and high speed assembly are achieved with PALNUT Sealer-Type Fasteners.



ADVANTAGES

Positive sealing. As nut is tightened, hollow hex design forces sealer around screw threads and into stud clearance hole.

Maximum thread sealing. Hollow hex, single-thread design allows several threads to be sealed.

Bonded sealer does not distort or come off during shipment or assembly.

Easy starting. Sealer does not bind in the threads; permits finger starting.

Resilient locking action avoids stud damage and body dimpling.

Write for free samples, details sizes, prices.

The PALNUT Company
70 Glen Road,
Mountainside, N. J.
Regional Sales Office
748 West Eight Mile Road
Detroit 20, Mich.

FULL PHASING

comes to the one-way clutch

from

BORG-WARNER

design it better—
make it better

engineering

Automotive and aircraft applications present special problems for one-way sprag clutches. For example, how to utilize their high theoretical torque-carrying capacity, and how to insure dependable operation under conditions of high shock loading and torsional vibration.

To solve these problems, Borg-Warner's Spring Division has engineered and perfected the first Double Cage *Full Phasing* One-Way Sprag Clutch. Designed for heavy duty service in the toughest applications, this new full phasing feature assures instantaneous engaging and uniform release of all sprags, full theoretical torque carrying capacity, high free wheeling speed without wear, long trouble-free operation.

Light, compact and readily adaptable to low-cost mass production, this new B-W full phasing clutch is performing successfully in automatic transmissions, torque converters, free-wheeling, overrunning and indexing devices and other applications.

It is one more example of how Borg-Warner's "design it better—make it better" policy serves American industry every day.

ENGINEERING B-W PRODUCTION

Benefiting almost every American every day

BORG-WARNER

THESE UNITS FORM BORG-WARNER, *Executive Offices, 310 S. Michigan Ave., Chicago*
DIVISIONS: ATKINS SAW • BORG & BECK • BYRON JACKSON • CALUMET STEEL • DETROIT GEAR • FRANKLIN STEEL • HYDRALINE PRODUCTS • INGERSOLL CONDITIONED AIR INGERSOLL KALAMAZOO • INGERSOLL PRODUCTS • INGERSOLL STEEL • LONG MANUFACTURING MARBON CHEMICAL • MARVEL-SCHEBLER PRODUCTS • MECHANICS UNIVERSAL JOINT • MORSE PESCO PRODUCTS • ROCKFORD CLUTCH • SPRING DIVISION • WARNER AUTOMOTIVE PARTS WARNER GEAR • WOOSTER DIVISION SUBSIDIARIES: B-W ACCEPTANCE CORP. • BORG-WARNER INTERNATIONAL • BORG-WARNER, LTD. • BORG-WARNER SERVICE PARTS • LONG MFG., LTD. • MORSE CHAIN • MORSE CHAIN OF CANADA, LTD. • REFLECTAL CORP. WARNER GEAR, LTD. • WESTON HYDRAULICS, LTD.

MORE OF THE GARLOCK 2,000

GARLOCK SILICONE RUBBER PRODUCTS

remain flexible at both high and low temperatures . . . ideal for gasketing on electrical and steam appliances, automotive and aircraft products. Won't stick to metal at high temperatures, either. And, silicone has no odor or taste, will not contaminate or corrode adjacent parts. Let us know your requirements. Garlock is equipped to handle even the most difficult thin wall extrusions.

Extrusions and molded parts of Silicone Rubber are only part of "The Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals to meet *all* your needs. It's the *only* complete line . . . it's one reason you get unbiased recommendations from your Garlock representative. Call him today or write for Folder AD-147.

THE GARLOCK PACKING COMPANY,
Palmyra, New York

For Prompt Service, *contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.*

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints

has proved useful. It has revealed the decrease in efficiency of the electrostatic filter with time, a fact which could not have been detected on the line-of-road by even the most critical visual examination. More field work will be done with centrifugal and oil bath filters to provide more precise data on their efficiency in regular service and on the effect of air flow velocity on filtering efficiency. Final evaluation of the test filters will be made after 12-month and 24-month wear measurements are available. (Paper "Air Filtration and Diesel Engine Wear —A Progress Report" was presented at SAE Golden Anniversary Diesel Engine Meeting, St. Louis, Nov. 4, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Based on Discussion

Richard Farr,
Farr Co.

Unless the air velocity impinging the particles on the oiled slide is the same for all tests, the collected particles will represent different proportions of each particle size actually present in the air stream. In general, the lower the velocity the fewer finer particles will be caught, and the particle count will be distorted in favor of the larger particles.

Present methods of air pollution sampling could be used readily to determine dust concentration in different districts. Millipore paper is very practical since it can be dissolved in acetone to make simple the particle size analysis of the collected samples. A centrifugal particle size analysis has been developed at the University of Minnesota which makes such analysis a matter of an hour's routine laboratory work.

A laboratory engine equipped with radioactive parts to determine particle size effect on wear rates as used by Watson, Hanley and Burchell, together with (1) particle size analysis and dust concentration determined in various districts plus (2) testing of air filters to measure efficiency versus particle size and service, could well be used for proper and economical selection of air filtering equipment for different field conditions.

L. S. Crane,
Southern Railway System

From a practical standpoint the wear measurements on the power assemblies will provide the most significant evaluation of filter efficiency. Each railroad will then need to evaluate the economic benefit to be derived from the reduction in wear which may be achieved with a specific design of filter.

C. E. Watson,
California Research Corp.

Our field tests show a wide variation

YEAR AFTER YEAR... MODEL AFTER MODEL...

MORE THAN ONE OUT OF THREE CARS ARE EQUIPPED WITH MUSKEGON PISTON RINGS

Efficient equipment plays an important part in Muskegon's capacity to deliver quantity orders on schedule. This bank of machines operated by one girl is typical of Muskegon volume production facilities.

BECAUSE MUSKEGON HAS WHAT IT TAKES

TO DELIVER THE GOODS ON SCHEDULE

Even the largest, most urgent orders for piston rings have consistently been delivered on time by Muskegon. Delivery in volume . . . when you need it . . . is due to the tremendous capacity of Muskegon's foundry, the biggest in the piston ring field, and the complete modern equipment and facilities at Muskegon necessary for grinding, machining and finishing any ring order.

Delivery on schedule takes capacity and facilities . . . and Muskegon has what it takes, having delivered rings for better than one out of three automobiles, year after year. If you require delivery of rings in volume, why not see Muskegon?

No matter what the design of the individual rings needed to fill the grooves of your piston, rely on Muskegon as your source.

MUSKEGON Piston Rings

DETROIT OFFICE:
521 New Center Building
Telephone: Trinity 2-2113

Since 1921... The engine builders' source!

MUSKEGON PISTON RING CO.
MUSKEGON, MICHIGAN
PLANTS AT MUSKEGON AND SPARTA

- **BRUSHES** for all rotating electrical equipment (Automotive-Aviation-Industrial-Traction, etc.)
- **GRAPHITE TUBE ANODES**
- **GROUNDING RODS** for protection against rust (earth and water types)
- **NON-WELDING ELECTRICAL CONTACTS**
- **VOLTAGE REGULATOR DISCS** (carbon piles)
- **WATER HEATER and PASTEURIZATION ELECTRODES**
- **BEARINGS**
- **WELDING RODS**
- **WELDING PLATES and PASTE**
- **RESISTANCE WELDING and BRAZING TIPS**
- **MOLDS and DIES**

"EVERYTHING IN CARBON BUT DIAMONDS!"

- **SPECTROGRAPHITE**
- **POROUS CARBON**
- **SEAL RINGS**
- **FRICTION SEGMENTS**
- **TROLLEY SHOES**
- **CHEMICAL CARBON and GRAPHITE ANODES** (Plain or treated)
- **CARBON RODS FOR SALT BATH RECTIFICATION**
- **CLUTCH RINGS**
- **ELECTRIC FURNACE HEATING ELEMENTS**
- **BRAZING FURNACE BOATS and FIXTURES**
- **CONTINUOUS CASTING DIES**
- **PUMP VANES**
- **PURE CARBON** . . . and many other carbon-graphite-metal powder products

STACKPOLE

WRITE FOR DETAILS ON ANY PRODUCT

STACKPOLE CARBON COMPANY, *St. Marys, Pa.*

in dust concentration due solely to the location of a power unit in a locomotive. If engine wear rates or performance of filter adhesives were being compared in this work, erroneous conclusions could have been drawn. Some control can be exercised to balance the total dirt load over a long period of time by rotating the location of test units in the locomotive.

H. R. Moos,
Caterpillar Tractor Co.

Assuming that more than one diesel unit is used in each train, it seems likely that the front engine would breath cleaner air than the following engine or engines. Rotation of the power units could average out this effect.

Even though the air velocities at the two locations are equal, the microscope slide technique is still questionable because of the fluid dynamics of the situation. The particle size distribution on the slide will differ from that in the air because the lighter particles will tend to follow the air around the slide while the heavier particles will impinge on the slide. Any measured distribution will be biased toward the heavier side.

Max Ephraim, Jr.
and
Robert I. Traver,
Electro-Motive Division, General Motors Corp.

The ability of the electrostatic type filter to collect particles is not questioned, but apparently dirt is not retained under vibration conditions. The retentivity of oil-coated surfaces as used on impingement filters does permit their operation under shock loads and heavy vibration conditions.

Comments by Author

There are three units to a train. Each test engine air filter was located in a cab unit, but each was placed in a different locomotive. The head-end cab unit was the operating unit while going in the forward direction. On the return trip the other cab unit was the lead since the locomotive was not turned around. Operation over one- and two-year periods will assure each unit contending with the same overall test condition.

Questioning the reliability of the microscope slide technique is valid from the theoretical standpoint. How far it affects the actual results is unknown, but for the purpose of the test the technique was considered adequate.

Since the bias of the microscope slide for the larger particles is operative at the lower size range limit of the dust, the method can be considered valid for the range of dust sizes that contribute most to engine wear.

In our experience there is no problem of the electrostatic filters being able to hold its dirt load. In fact, the dirt deposits collected on the collector plates are difficult to remove because of their oily consistency.

You don't have to PAINT when you use

HUNTER DOUGLAS
Pre-painted
ALUMINUM STRIP
and you get a *BETTER* PRODUCT FINISH!

Manufacturers using strip stock can now enjoy *complete freedom from painting* on a wide variety of products and get a *far better finish* in any desired color... at worthwhile cost savings!

Hunter Douglas Pre-Painted Aluminum Strip provides the answer... besides eliminating handling time, it avoids a healthy capital investment in conveyor systems, special spray booths and equipment, baking ovens, etc. It ends forever the problem of quality control, lack of color uniformity, rejects from undesirable runs and drips! Moreover you get a *better* finish, proved by the billions of feet of Hunter Douglas' Flexalum venetian blind strip material already in use. With Hunter Douglas Pre-Painted Aluminum Strip you don't *need* a painting department!

Simplifies forming,
Eliminates painting,
Makes products more saleable!
Investigate the possibilities of Hunter Douglas Pre-Painted Aluminum Strip now!

FORMS READILY WITHOUT DAMAGE TO PAINTED SURFACES—Now parts can be readily roll formed, embossed, stamped, even *deep-drawn through several successive stages* without marring, cracking or scratching this hard, bright, lustrous, pre-painted surface!

MAXIMUM ADHESION—Chemically prepared surfaces are specially primed, followed by a second coat of enamel—with each coat individually baked. Bond is exceptionally strong. Edges cut clean and sharp, are free from flaking and chipping.

EXTERIOR DURABILITY COMPARABLE TO AUTOMOTIVE FINISHES—Unusually color fast in sunlight, resistant to heat and cold; successfully passes extreme 500 hour, 90°, 20% salt spray test with no lifting or blistering.

WIDE COLOR SELECTION—Colors to harmonize or contrast with other décor.

STOCK SPECIFICATIONS—If your production can use mill quantities (20M lb./minimum) in widths up to 8", nominal thicknesses, get our quotations.

Hunter Douglas Aluminum Corporation

Detroit Sales Engineering Office:
16722 E. Warren Ave., TUxedo 2-0232

HUNTER DOUGLAS ALUMINUM CORPORATION • DEPT.SA-6, RIVERSIDE, CALIFORNIA, OVERLAND 3-3030

New Members Qualified

These applicants qualified for admission to the Society between April 10, 1956 and May 10, 1956. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Atlanta Section

Jarma E. Dixon, Jr. (A), Willie J. (Jack) Kile (A), Lewis A. Rumph (M).

Baltimore Section

Charles D. Helm (M), John W. Lippert (M), Robert S. Seligman (A), Harry J. Stubbs (A).

British Columbia Section

J. Ross Lint (A).

Buffalo Section

Frederic J. Watkins (A).

Canadian Section

George E. Bausor (M), Raymond J. Lambert (M), Alexander E. Johnston (M), F. Bruce Pillman (A).

Central Illinois Section

Donald A. Denniston (A), Swayne Garrison (M), Wilbur L. Hertenstein (J), Melvin J. Olson (M), Neil Swartzbaugh (J), H. Walter Zerlaut (M).

Chicago Section

Virgil D. Angerman (A), Martin T. Dyke (M), John W. Ferguson (M), Roy E. Holmgren (J), Anthony J. Jablonsky (M), W. Gordon Jarvis (M), James W. Kelley (M), Lester J. Larsen (M), Arthur R. Michaels (J), Hamilton Migel (M), Robert F. Prihar (J), John F. Schott (M), Dr. Philip C. White (M), Vincent J. Zegers (M).

Cincinnati Section

Gerald E. Briggs (A), George E. Grega (J), Ralph Medros (A).

Cleveland Section

Richard Ray Azeltine (J), Robert H. Braun (M), William C. Hutchings (J), Donald W. Partain (M), Don C. Price (J), Louis J. Stankiewicz (M), Louis J. Sykora (M), Walter J. Van Uum, Jr. (A).

Colorado Group

Frank J. Kunde (A), Chester L. Wentworth (A).

Dayton Section

Chester W. Holmes (M), Joseph H. McNinch, Jr. (J), Clare R. Weaver (M).

Detroit Section

J. Milton Agar (M), H. A. C. Anderson (M), Robert A. Anderson (A), Richard C. Bahnmiller (J), Walter J. Barbish (M), L. Earle Bretz, Jr. (A), John Burman (A), Donald A. Caley (J), Lawrence J. Cavanaugh (M), Aldo Ceresa (A), Daniel J. Clifford (A), Roger H. Compton (M), Roderick Craves (M), Linn F. Cummings (A), A. B. Curtis (M), Ernest A. Dacey (M), Robert E. Dale (A), John Eric Desmond (M), Merle B. Easter (J), George Ewdokimoff (M), Frank J. Falk (M), William J. Freyermuth (J), Raymond A. Gallant (M), C. W. Gumbert (M), Robert L. Hensel (M), Eugene R. Karrer (M), Jerome Liebow (J), Wade R. Marett (M), C. T. McClure (A), Harley G. McIntosh (M), Walter K. McPherson (M), W. Mitchell Middleton (M), Carl J. Miller (M), Richard A. Mills (M), Robert D. Montgomery (M), Clarence Morgan (J), C. Charles Mortimore (M), Paul D. O'Brien (M), G. A. Panier (M), Frank M. Parcella (J), Matthew C. Patterson, Jr. (J), Irving L. Pierce (M), Ferdinand C. Pringnitz

TOP PERFORMANCE
for HEAVY HAULING

BORG AND BECK
"E" TYPE CLUTCH

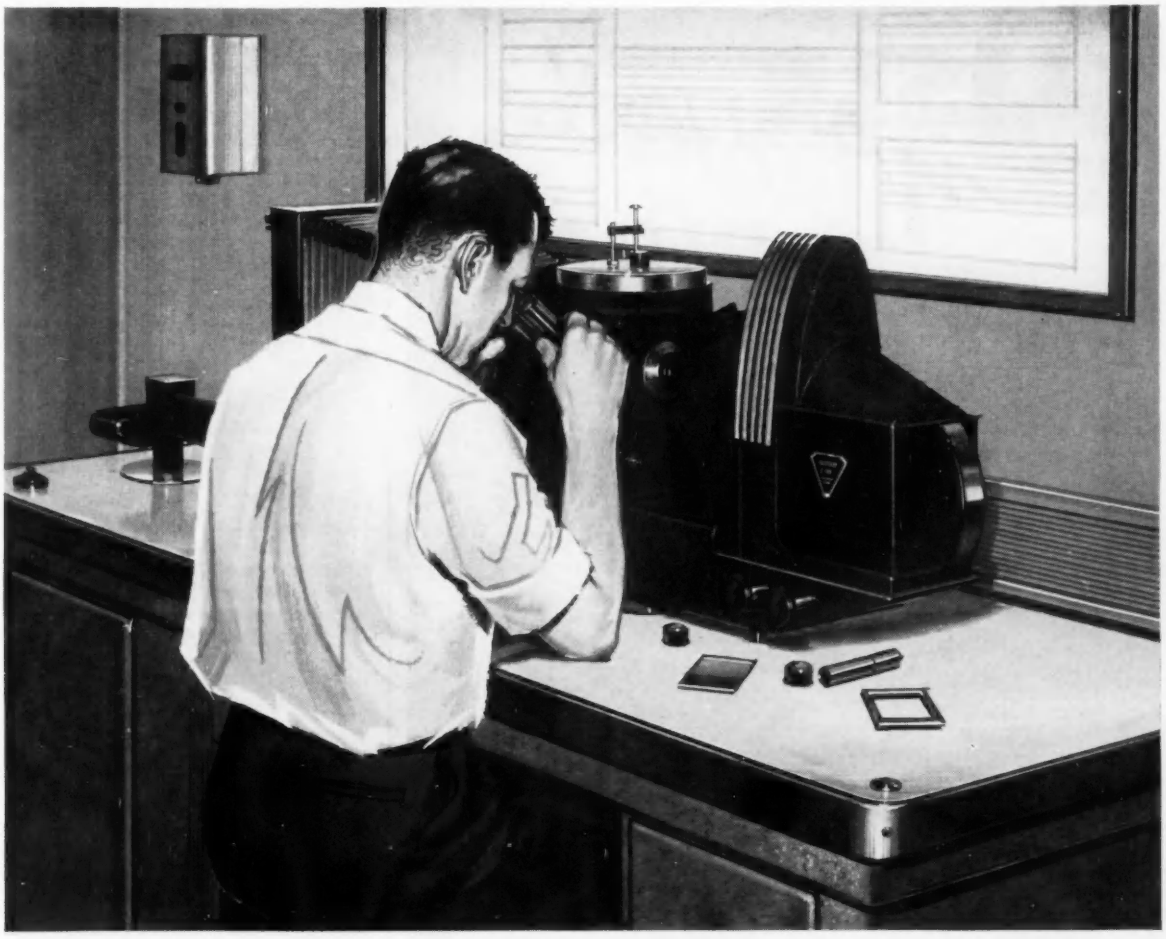
- *Husky—Heavy Duty*
- *"Strap Drive"*
- *Friction-Free*
- *Smooth Engagement*
- *Minimum Maintenance*

Engineered by BORG & BECK
for that vital spot where power takes hold of the load

ENGINEERING B-W PRODUCTION

BORG & BECK DIVISION
BORG-WARNER CORPORATION • CHICAGO 38, ILLINOIS

AT CARTER . . .



Metals have no Secrets

By the time metal samples get through Carter's test laboratory their past history is bared and future performance predicted. The metallograph shown above discloses grain structure. In addition, materials are stretched, compressed, twisted, fractured, exposed to corrosion, heat and cold.

This is just one of many materials tested in this modern laboratory. Gasket, glass and every other material used in Carter fuel system products must meet rigorous requirements. Our aim is to remove every possible cause of trouble . . . to constantly lengthen the long and dependable life of Carter carbureters, fuel pumps and fuel filters.

CARTER CARBURETOR CORPORATION, St. Louis 7, Missouri

A Division of ACF INDUSTRIES, INCORPORATED

LISLE Magnetic PLUGS

Worth Looking into for Your Products!

BEFORE

AFTER

If you are looking for sure, low cost protection against excessive wear in your product, it will pay you to check the Lisle Magnetic Plug catalog. Interesting application data may suggest how you can benefit by using Lisle Magnetic Plugs in place of ordinary drain plugs in any gear case. "Before" and "after" views at left show how the powerful magnet in the Lisle Plug pulls abrasive metal particles out of the lubricant.

Send for Free Sample Lisle Magnetic Plug for testing in your product. State size and type of plug desired.

LISLE Corporation
CLARINDA, IOWA

New Members Qualified

continued

(M), Clyde ("Bud") Reeme (A), John J. Retich, Jr. (J), Frederic H. Riebling (A), Calvin J. Sandberg (J), Frederick Schwartz (A), Theodore W. Selby (J), H. Clare Shepard (J), Robert C. Sheridan (J), John G. Soroka (M), Hans R. Stauber (J), Warren C. Steele (J), Raymond Stevens (M), Charles B. Stevenson (J), MacDonald S. Stuart (M), Gregory R. Taylor (A), James Thornton (J), Howard B. Tranum (M), John L. Walker (M), Edward J. Walsh (J), Martin Wurzer, Jr. (J), Edward A. Zeschin (J), C. Raymond Zink, Jr. (A).

Hawaii Section

Lewis W. Erwin (M).

Indiana Section

Clyde S. Berry (M), Charles M. Ellis (J), Alvin T. Hanson, Jr. (M), Lawrence L. Harrison (A), Charlie M. LaVine (M), Herbert L. Porter (M), Louis J. Zimmel (M).

Kansas City Section

Carroll Abrams (J), D. Robert Brown (M), Walter J. Janczewski (J).

Metropolitan Section

Robert S. Aries (M), Charles J. Casaleggi (J), William D. Dilday (M), William J. Dunbar (A), Murray H. Edson (M), Thomas R. Evans (M), David F. Greene (M), Robert P. Irwin (J), Helmut H. Krapp (M), W. M. Langton (M), Milton E. Murdock (A), Alexander H. Popkin (M), Wilfred C. Rippe, Jr. (M), Warren M. Spear (M), Franklin Whitescarver (A).

Mid-Continent Section

Joel L. Carson (J), J. E. Donnelly (M), H. Dale Jordan (A).

Mid-Michigan Section

John L. Cohoon (J), Forrest S. Fisher (M), Arnold G. Kruse (A), James P. Miller (J), Jack P. Ridenour (M).

Milwaukee Section

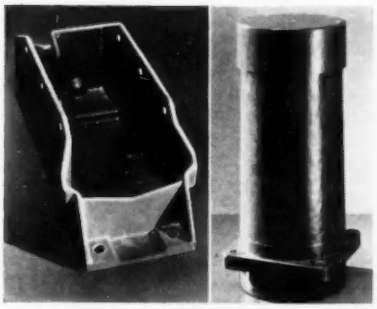
R. G. Everist (M), Donald A. Henrich (J), Arthur R. Long (M), Daniel F. McCormick (M), Max R. North (M), Robert E. Wenzel (J), H. Louis White (M).

Montreal Section

John M. Forde (J).

continued on page 142

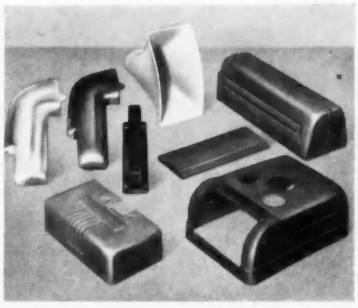
When to use HETRON® polyester



1. To make your own pre-mix. The range of properties offered in HETRON resins gives you the performance needed for almost any pre-mix molded part. Fire resistance, heat resistance, and high strength are built-in.

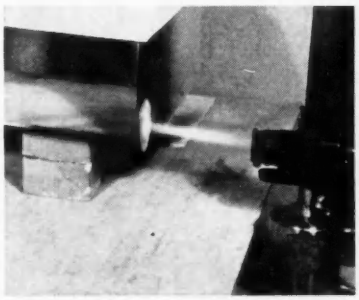
Physical Property		Rigid Resins		Semi-rigid Resin
		HETRON 92	Avg. 10 Others	HETRON 32A
Flexural Strength, PSIx10³	Room Temp.	38.6	36.4	41.8
	180°F.	25.0	18.6	23.5
Flexural Modulus, PSIx10⁶	Room Temp.	1.88	1.61	1.82
	180°F.	0.90	0.79	0.85

2. When high flexurals are important. You get extra flexural strength with HETRON. Other advantages: unusually high impact strength; very high heat resistance; excellent tensile strength; very low water absorption.



3. When you want a baked-on finish. Parts like these, molded with HETRON, take an alkyd finish baked on at high temperatures for 90 minutes—with no surface crazing. There's practically no surface shrinkage during cure.

4. For aircraft. Some HETRON resins, including semi-rigid HETRON 32A, are manufactured to meet MIL-R-7575A, Types I and II. HETRON 92, with up to 10% added styrene, meets MIL-R-7575A, Types I, II, and III.



5. When you need fire resistance. HETRON won't burn except under direct hot flame—snuffs out as soon as flame source is removed. Here, test structure is virtually unaffected by 15-minute exposure to hot blowtorch flame.

6. When your product must meet building codes. If you need specific flame-spread data, often required by building officials, choose a HETRON-based material. This fabricated sheet, for example, has Underwriters' listing and label.

You get more than fire resistance with HETRON. Specify it for its outstanding strength, or its excellent molding properties—and get fire resistance, too, as a desirable "extra." To discover how well HETRON can meet your design requirements, send for the complete data file on HETRON resins. Ask also for list of reputable fabricators working with HETRON.

DUREZ PLASTICS DIVISION

HOOKER ELECTROCHEMICAL COMPANY
3606 Walck Road, North Tonawanda, N. Y.

HOOKER CHEMICALS PLASTICS

6-741

New Members Qualified

continued

New England Section

Raymond L. Cleveland (M), Stanley H. Franklin (M), William S. Lewis (J), C. O. Sparhawk (M).

Northern California Section

Donald W. Behrens (A), John W. Chung (M), Dwight B. Sale (J), Carlos M. Valdivia, Jr. (J).

Northwest Section

Robert B. Cheminant (A), W. M. Fiander (J).

Oregon Section

Harry C. Jacobsen (A), H. C. Palmer (A), Stanley W. White (A).

Philadelphia Section

Shirley C. Bartlett, Jr. (M), Messoud Kiachif (M), Rodolphe L. Richard (M), Frank J. Woechan (M), Joseph J. Zaiss (M).

Pittsburgh Section

Lewis U. Davis (M), Gianni A. Dotto (M), Edward M. Flaherty (M).

St. Louis Section

Robert G. Bakula (M), Robert J. Lewis (A), William D. Sims (M), Guy A. Turner, Jr. (A).

Salt Lake Group

William W. Graham (J).

San Diego Section

John D. Donaldson (M), Elias L. Margolin (M), Arthur J. Quinlan (A).

Southern California Section

Allan F. Bell (M), Horace E. Fansler (M), G. A. Fitzpatrick (M), J. Monte Frodsham (A), Giles A. Kendall (M), Milton A. Miner (M), Frank A. Moody (A), Ralph W. Moss (A), John F. Peyton (M), Clyde H. Reed (J), L. Eugene Root (M), Jack H. Zillman (M).

Southern New England Section

Frank O. Hamlet (M).

Spokane-Intermountain Section

William P. Eldenburg (A).

Syracuse Section

James H. Williams (A).

Texas Section

Leslie S. Dame (M), Merril V. Riccius (M), Allen B. Thompson (M).

Texas Gulf Coast Section

William S. Dixon (J), A. W. Elrod (M), Jack W. Richardson (M).

Twin City Section

Hendrie J. Grant (M).

Virginia Section

William I. Bragg (A).

Washington Section

George F. Hall, Jr. (M), Comdr. Alfred van der Hoeden (A).

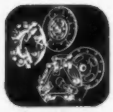
Western Michigan Section

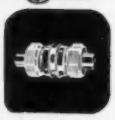
Raymond C. Kleber (M).

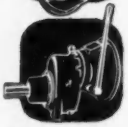
continued on page 144

ROCKFORD

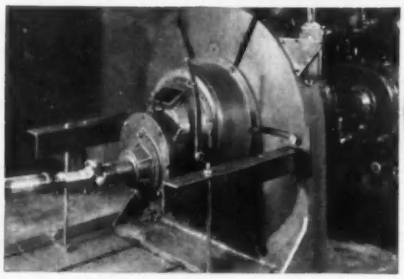
MEMO
Clutch must be conservatively rated—



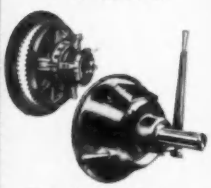




ROCKFORD POWER TAKE-OFFS are designed for generous overload capacity within the fields of service recommended by Rockford Clutch engineers.



POWER



TAKE OFF

Large ROCKFORD clutches, power take-offs and speed reducers are tested for torque, engaging pressure, release, temperature, gear strength, bearing endurance and clutch facing wear on this 400 H. P. diesel powered, electric dynamometer. Let ROCKFORD engineers utilize this machine to improve your heavy-duty power transmission controls.

ROCKFORD
Clutch Division
BORG-WARNER
316 Catherine St., Rockford, Ill.

CLUTCHES

WHY BRAKES OF ALUMINUM INSTEAD OF CAST IRON?

Aluminum has many advantages over cast iron for brakes. Aluminum weighs only ⅓ as much as cast iron. Aluminum has 3 times the heat dissipating ability of cast iron. Cast iron brakes dissipate heat slowly and build up high temperatures. Auto Specialties all aluminum Double-Disc Brakes get rid of heat fast. Run cooler. Do not fade.

Auto Specialties aluminum Double-Disc Brakes have passed tests that verge on the unbelievable. Imagine pushing the brake down hard and making hundreds of consecutive, abrupt, panic stops from 50, 60 and 70 mph. Then repeated consecutive fast stops from 80, 90 and 100 mph. And this is just the beginning. After these stops, thousands of other rugged stops—many of these with no time in between for the brakes to cool. At the end of several thousand stops, the amazing Auto Specialties aluminum Double-Disc Brakes were still performing like a champion. No other brake has ever withstood such punishment. Thus, based upon this proof of effectiveness, we feel that Auto Specialties Double-Disc Brakes are ready for adoption. And we also think these tests are a good indication of why we construct our brakes of aluminum.

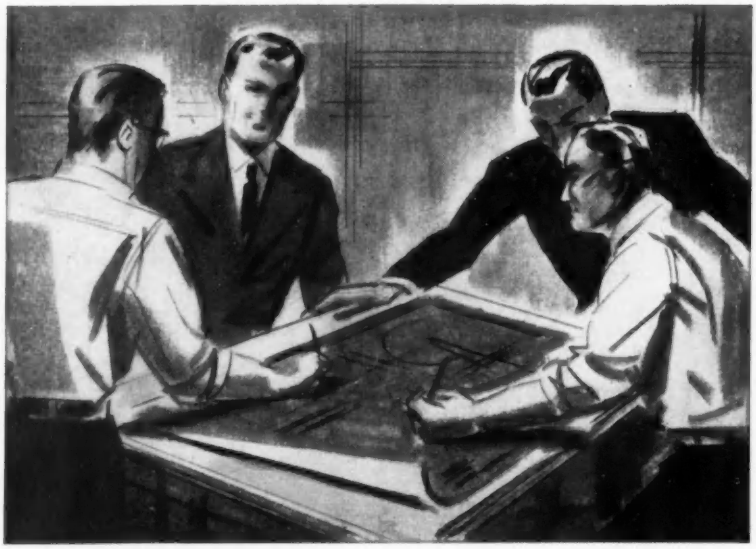
WHAT ABOUT COST?

There has been a general misconception about the cost of these brakes. Auto Specialties engineers will gladly consult with car manufacturers regarding cost, production, adoption and delivery for automobiles of any make that we are not negotiating with now.

AUTO SPECIALTIES MFG. CO., INC.

SAINT JOSEPH, MICHIGAN

Manufacturing for the automotive and farm machinery industries since 1908
Plants also at Benton Harbor and Hartford, Michigan and Windsor, Ont., Canada



Have your own staff of consulting engineers

—*at no cost*

Are competitors, like clever boxers, using basic product improvements to keep you continually off balance? Those punches can be mighty effective, and tough to block.

Talk to Clark—a full-scale, 'round-the-table discussion of all problems relating to this Vital Area of product performance: *the transmission of engine torque from flywheel to point of traction.*

Here is a full staff of good engineers of true top-drawer capacity: backed by Clark's half-century of specialized engineering experience concentrated on that Vital Area. That rich know-how is yours to command: Cost? . . . none.

- **Certain manufacturers of agricultural and industrial machinery, on the defensive, asked Clark to design wholly new, functional drive units—and got them. Ever since, their competitors have had the headaches.**
- **For its own new Michigan tractor shovel, Clark engineers created a revoluntionary power train —and captured immediate leadership.**

Here is a fundamental usefulness that welcomes challenging problems—that costs nothing, yet may well lead to selling advantages of incalculable value.

Let's talk about it—no cost there, either.

CLARK® EQUIPMENT

CLARK EQUIPMENT COMPANY
Automotive Division
Buchanan 5, Michigan

New Members Qualified

continued

Wichita Section

Wilson Simmons (A).

Williamsport Group

George D. Lenington (A).

Outside Section Territory

John S. Adams (M), W. R. Alford (J), Benjamin G. Gray (A), Charles W. Haagen (M), John L. Heinlein (M), James E. Kerwin, Sr. (A), James C. Malone, Jr. (M), William R. McCann (M), C. L. Oheim (M), William J. Plunkett (A), Roger A. Stalter (M), W. C. Truckenmiller (M), Paul R. Welch (M).

Foreign

William A. Bruinsma (J), Saudi Arabia; Edwin J. Gartrell (M), Malaya; Norman Greenhalgh (M), England; Heinz Hoffmann (M), Germany.

Applications Received

The applications for membership received between April 10, 1956 and May 10, 1956 are listed below.

Alberta Group

Robert Moar, Joseph R. Reid.

Atlanta Section

Gerald E. Misel, Albert E. Terril, Wright W. Warr.

Baltimore Section

Glenn W. Randolph.

British Columbia Section

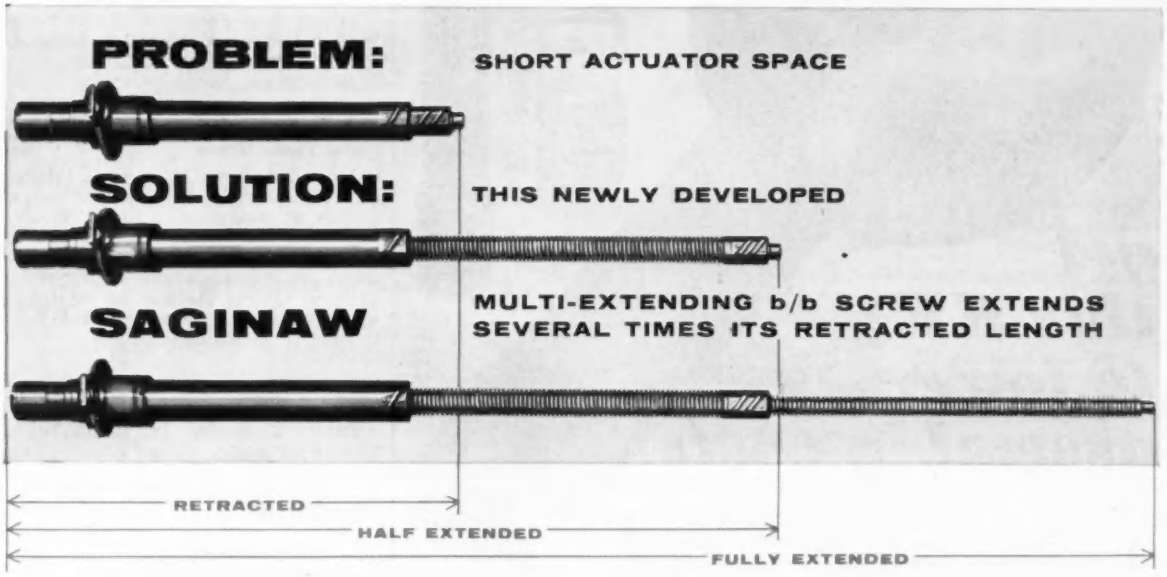
Harvey G. Blackmun, Edward Kaila, Abel J. Leger, Jack L. St. Ruth, Samuel J. Scagel, William Wong.

Buffalo Section

Robert H. Meyerhans, Richard F. Thurston.

continued on page 146

Saginaw SOLVES ANOTHER POSITIONING PROBLEM!



Now, the pioneer in the development of the precision ball/bearing screw and spline offers you another great engineering advancement: *a practical and dependable solution for your most difficult actuator space problems!*

The Saginaw Multi-Extending b/b Screw is the answer design engineers have been seeking for years because:

1 It provides extended lengths in approximate multiples of its retracted length

2 It will carry a far higher load than any other telescoping device in its class

3 It is far more practical and troublefree than previously available telescoping units

4 It assures dependable, precise positioning within thousandths of an inch

PLUS ALL THESE PROVED SAGINAW ADVANTAGES

- *90% efficiency guaranteed*
- *Requires up to 1/5 less torque than Acme screws*
- *Less drain on power supply*
- *Conserves space and weight*
- *Operates dependably at extreme temperatures*
- *Functions perfectly with only initial lubrication*

Can be built in a wide range of diameters and extended and retracted lengths

Saginaw ball bearing Screw

SAGINAW STEERING GEAR DIVISION OF GENERAL MOTORS • Saginaw, Michigan

MAIL COUPON TODAY FOR NEW ENGINEERING DATA BOOK

Saginaw Steering Gear Division
Ball Bearing Screw & Spline Operation
General Motors Corporation
Dept. 5E, Saginaw, Michigan

Please send your b/b Screw and b/b Spline Engineering Data Book to:

Name—Title_____

Firm_____

Address_____

City_____ Zone____ State_____

get this KEY to lower assembly costs

There are new opportunities for cutting assembly costs in the "Key Locking" feature of KELOX Inserts and Studs. You can improve your product and reduce assembly costs with KELOX because these fasteners—

1. Provide a positive lock between insert or stud and parent body.
2. Provide higher stress allowable per space required.
3. Are simple to install and remove.
4. Make maximum use of tapped hole.
5. Afford considerable reduction in assembly weights.
6. Save space and improve product design.
7. Can be serviced in field without special tools.
8. Require no special threads.

KELOX Fasteners are part of a family of universally used PHILLIPS PRODUCTS that are designed, developed and distributed by a worldwide organization.

This highly specialized, technical group will be glad to assist you with your fastener problems. Use coupon below to get more facts on KELOX!

KELOX

Fasteners, Inc.

580 Fifth Avenue
New York, New York

SALES REPRESENTATIVES—

Universal Fasteners Co.
Centerville Road, P. O. Box 449
Sturgis, Michigan

F. D. Barringer Company
542 Spring Street, N.W.
Atlanta 3, Georgia

Monogram Manufacturing Co.
8557 Higuera Street
Culver City, California

D. R. & W. Technical Service Company
P. O. Box 4
East Hartford, Connecticut

Scott Fittings Limited
339 Bering Ave., P. O. Box 169
Toronto 18, Canada

3395

Please send me technical data on KELOX Inserts and Studs

Name ..... Title .....

Company .....

Address .....

Product being assembled .....

Applications Received

continued

Canadian Section

Robert Earl Bolton, E. R. Current, Fred J. Kavanagh, Mokal G. Morgan, Alfred S. Rae, Arthur J. Searles, William H. Wolfhard.

Central Illinois Section

Jack M. Angevine, Charles O. Bilyeu, Carl W. Blackwell, Jr., Roger L. Boggs, Orville H. Cannedy, John S. Eisele, William T. Fall, Donald L. Hildebrand, Clay L. Hutchings, Carl E. Kacynski, James H. Lambie, John R. Layman, Vincent Licari, Thomas M. Murphy, Alfred W. Newton, W. Miller Owen, Roy C. Ross, C. A. Woodley.

Chicago Section

Fenton L. Bagley, Jr., Hugo Coello, Leonard J. Kowal, Robert R. Kowalski, Harry R. Levey, Joseph F. Lewis, Ivan F. Priddy, Max Rosenberg, Chester C. Shelton.

Cincinnati Section

Lawrence B. Venable.

Cleveland Section

Ralph B. Beardsley, W. C. Burton, Douglas S. Jones, Wayne B. Kelley, Robert J. Morse, Robert G. Oakley, H. P. Rassbach.

Colorado Group

Homer K. Ryder.

Dayton Section

Robert P. Anthes, Richard H. Kerr, William B. Stelzner, Jr., William O. Yeazell.

Detroit Section

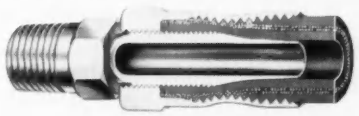
William J. Andrews, Edmund T. Baumgartner, Herbert W. Behlow, William J. Bell, Charles Belsky, Lucien C. Bohley, Raymond I. Bradley, Jr., Wayne V. Brien, Robert Earl Brown, Gerald L. Burgess, Albin Chaplin, Laurence S. Clark, V. E. Clark, Robert L. Collins, Leon A. Corral, Gene A. Crockett, Robert H. Dougherty, Don B. Ellis, Kingston B. Ellis, James M. Erkert, Mathias J. Esser, Edward F. Fort, Charles W. Frederick, Jr., Robert A. Gailey, Philip J. Garthe, Russell Frederick Gee, George W. Gibson, Jr., Nubar M. Hachigian, Gregory Robert Hagan, Clayton E. Hallickson, Charles N. Hughes, Donald R. Jagusch, Ernest A.

WEATHERHEAD

First in components for HYDRAULIC SYSTEMS

Look at anything . . . anywhere in the world . . . in hydraulics, diesel power or machine tool applications . . . equipment for instrumentation, oil drilling, mining, road building, petro-chemicals or even atomic power . . . chances are the vital air and fluid lifelines are secured with WEATHERHEAD.

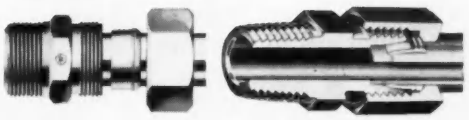
Reusable Hose Ends



Bulk Hose

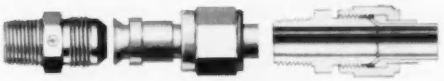
Hose Assemblies

ERMETO®



SAE 37° FLARE

3-PIECE

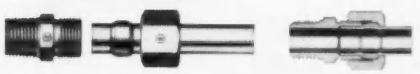


2-PIECE

SAE 45° FLARE

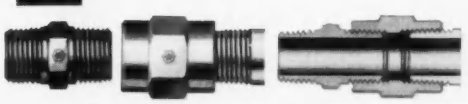
INVERTED FLARE

COMPRESSION

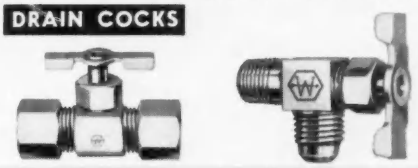


SELFALIGN®

PIPE



DRAIN COCKS



WEATHERHEAD

The only single-source hydraulic hose and fitting line.

Available coast-to-coast through Weatherhead distributors.

WEATHERHEAD

FIRST IN HYDRAULIC CONNECTIONS

THE WEATHERHEAD CO., FORT WAYNE DIVISION

Dept. AD-6, 128 West Washington Blvd., Fort Wayne, Indiana

In Canada: The Weatherhead Co., Ltd., St. Thomas, Ontario

Applications Received

continued

Johnson, Russell F. Kauffman, Arvan F. Kent, Richard L. Kessler, Harry E. Koontz, Dimitri Kosacheff, Anthony Krenzer, H. J. LaDouceur, Jr., George W. Leineke, Arthur S. Lennox, Henry J. Leonard, Richard L. Lerner, Michael Marinetti, Manford E. Mason, Werner Munz, Edwin E. Nelson, Howard Lee Pierle, John W. Ruffin, Kenneth Samples, James F. Scharfenberg, Richard J. Schlitters, William A. Scott, Fred W. Shoemaker, Peter J. Shuttleworth, John M. Skupin, Miles B. Spickler, Earle H. Sterling, David M. Sunderland, Bernard M. Thun, Russell Treptow, Howard E. Werner, Lloyd C. Wiand, Wendell M. Young.

Hawaii Section

Frederick L. Spafford, Jr.

Indiana Section

Warren H. Chase, James R. Eddy, D. L. Feaster, Robert E. Franke, Elton B. Long, Eugene E. Paul, Dwight R. Shumann, John D. Zartman.

Metropolitan Section

Robert E. Abbott, Henry Albert, Ralph Bonafede, Frank X. Burke, Victor T. Carbone, Eugene S. Corner, Bernard Diamond, Eugene T. Doyle, Robert J. Eden, Robert L. Hutchins, Robert B. Karp, David G. Kempner, Bramwell R. Linden, Maurice Paleschuck, William J. Pick, Joseph M. Rodriguez, Jr., Marvin L. Rosenfeld, Louis J. Sattarelle, Daniel P. Schwester, John B. Slack, William S. Thomas, Richard E. Townsend, Otto William Vathke, David L. Yeomans.

Mid-Continent Section

Herbert E. Salter.

Mid-Michigan Section

Fortunato F. Barberis, Donald J. Bullock, Joseph P. Casassa, Marion L. Davis, David A. Dickerson, Harley E. Fortier, John G. Mezoff, Donald R. Reinertson, Robert J. Richards, Francis A. Sanders, Robert W. Smith, Richard S. Stinnett, Hal J. Sutton, Robert S. Williams.

Milwaukee Section

Robert A. Bryce, Robert Couchman, Jr., James H. Detenbeck, Russell C. Gubbins, Meredith C. Thomson.

Mohawk-Hudson Section

Gene P. Baynes, Robert B. Lauridsen.

Montreal Section

Leonard Brook, James W. Calder, Orest Cochkanoff, Orrin M. Firth, Leo Lacombr.

New England Section

Ralph D. Baker, Leopold B. Blum, III, Philip C. Wolff.

Northern California Section

Clessie L. Cummins, Jr., Jack W. Ehlen, Peter H. Hertel, Frank Mithen.

Philadelphia Section

Robert H. Butler, Alexander H. Du-

Up where the boiling point is low...

...Vernatherm® controls assure correct operating temperature for these BIG Diesel Machines

Here is your answer to tough coolant problems on Diesel and heavy-duty gasoline engines . . . Detroit Controls Vernatherm . . . a solid-charged thermostat that will take all the punishment big engines and rough duty can give it, and still give positive, precise coolant control *indefinitely.*

Pioneered by the Detroit Controls Corporation, these Vernatherm thermostats have a reputation for solving knotty problems in the roughest kinds of service.

Call on a Detroit sales engineer for application assistance . . . or write for Bulletin 213, which gives basic data on Vernatherm Controls and their function in modern engine design.

YOU LIVE BETTER WITH DETROIT CONTROLS

DETROIT CONTROLS
CORPORATION
5900 Trumbull Ave., Detroit 8, Mich.
Division of American-Standard

Representatives in Principal Cities
Canadian Representatives: RAILWAY AND ENGINEERING SPECIALTIES, LTD., Montreal, Toronto, Winnipeg.

AUTOMATIC CONTROLS for
REFRIGERATION • AIR CONDITIONING • DOMESTIC HEATING • AVIATION • TRANSPORTATION • HOME APPLIANCES • INDUSTRIAL USES

Accurate Universal Joint Engineering Assistance—

—Available for Design Engineers

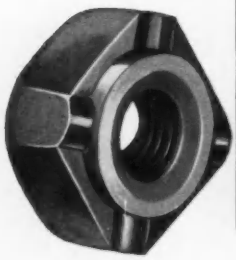
MECHANICS Roller Bearing UNIVERSAL JOINTS *accuracy* has met every aircraft need of the largest bomber and the smallest helicopter. When strategic aircraft requirements indicated a NEW type of universal joint, MECHANICS engineers developed it. Design, metals, machining, tolerances, heat-treating, hardening, stamina, balance and lubrication—all were adapted to aircraft precision. Design engineers may have the benefit of this universal joint know-how by sending for the aircraft bulletin shown at the right. Our general catalog, containing helpful universal joint engineering data and tracing kits, also will be sent to engineers, upon request. Let MECHANICS engineers help design and build universal joints that are exactly suited to the power transmission needs of *your* product. The competitive advantages that designed-for-the-job MECHANICS Roller Bearing UNIVERSAL JOINTS provide, are well worth investigating.

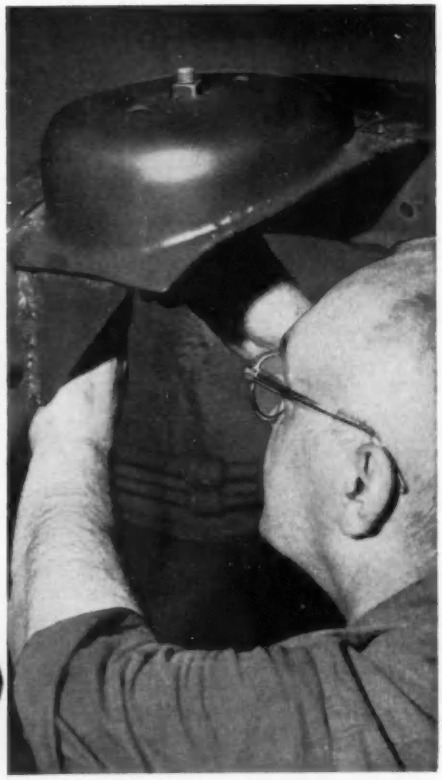
MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2022 Harrison Avenue, Rockford, Illinois

MECHANICS
Roller Bearing BW
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

SPEED UP THE FABRICATING, FASTENING AND ASSEMBLING OF METAL PARTS WITH





MIDLAND
WELDING NUTS!

Midland Welding Nuts may be the answer to your dreams if you're in a business which fabricates, fastens, or assembles metal parts—OR, if you're a designer of products incorporating such parts.

Midland Welding Nuts are welded to the parts to be worked so that bolts can be turned into them speedily—without the need for any device to hold them in place.

They're just the ticket for those hard-to-get-at places. And they stay put—will not work loose or rattle.

Relied on by manufacturers the world over—and specified universally by product designers—Midland Welding Nuts will lower your assembly costs, speed up operations all along the line for you.

Write or phone for complete information!

The MIDLAND STEEL PRODUCTS COMPANY

6660 Mt. Elliott Avenue • Detroit 11, Michigan
Export Department: 38 Pearl St., New York, N. Y.
Manufacturers of
Automobile and Truck Frames • Air and Vacuum Power Brakes
Air and Electro-Pneumatic Door Controls

Applications Received

continued

Puy, John H. Hopkins, Eugene J. Karlik, Russell E. Warmkessel.

St. Louis Section

Paul M. Dabney.

San Diego Section

Thomas C. McClure, Paul R. Shipps, Edward A. White, John Q. A. Wickham.

Southern California Section

Anthony P. Casagrande, Roland B. Clark, Leo E. Denning, Dino Dini, Donald A. Dutra, Theodore L. Gershun, Robert W. Graves, John C. Holman, Paul T. Hughes, James H. Miller, James A. Ray, John H. Rudy, James C. Simcoe, Jr., Lyle E. Thompson.

Southern New England Section

Robert S. Cutler, James B. Funk, Jr., John E. Godown, Brayton A. Porter

Spokane-Intermountain Section

James J. Manning.

Syracuse Section

Robert Lee Wilkinson.

Texas Section

Harold J. Harmer, Roderick L. Zorn.

Texas Gulf Coast Section

Woodrow F. Barker, Ralph C. Cooley, Jr., Lester L. Ingram, John Peter Peet.

Twin City Section

Chester F. Lenik.

Virginia Section

E. H. Wickline.

Washington Section

Sidney F. Williams, Jr.

Outside of Section Territory

Frank Allgaier, Arthur F. Cross, Le-Roy H. Ellsworth, Henry W. Hanley, Jim Leon Marshall, Richard L. McGee.

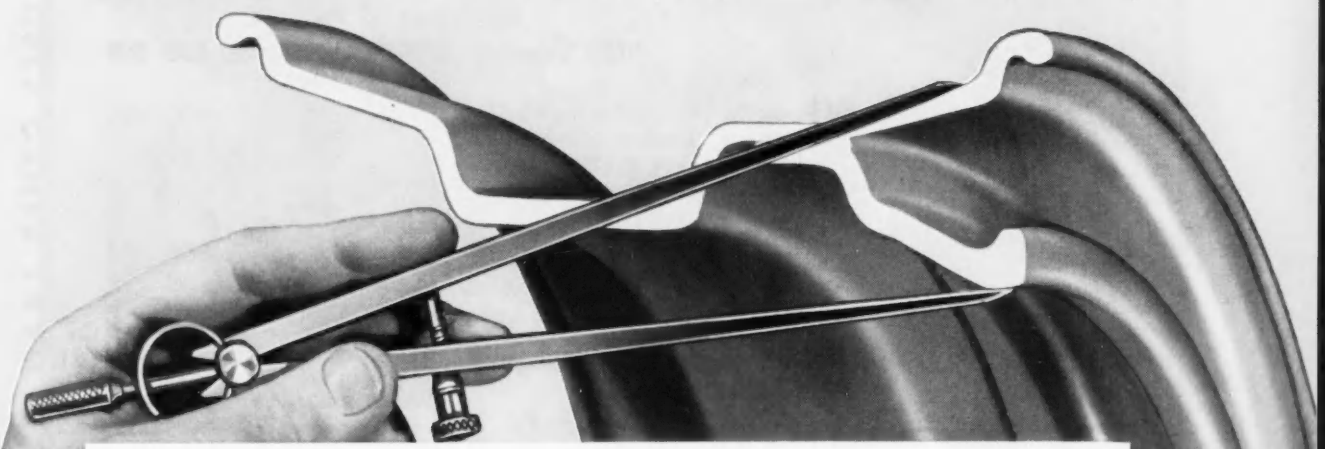
Foreign

Frank W. Baggett, England; Clifford P. Brown, England; Lennox S. Honeyborne, South Africa; Halvor Otto Karud, Norway; Geoffrey O. Phillips, S. Africa; Joseph Wright, England.

NO WOBBLE ...

in Firestone ONE-PIECE RIMS

Because They're Engineered to Closer Tolerances than Any Other Rim!

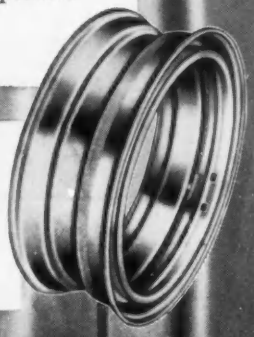


Here's Why . . .

No Other Rim has this Open Face Mounting Ring . . . It Permits Both Inside and Outside Dimensions to be Controlled . . .

PRECISION fit is necessary for proper alignment. If the outside of the rim is not perfect, you have an out-of-round wheel causing a bumpy ride. If the inside dimension is not engineered to closest tolerances, the rim fits loosely on the wheel, resulting in improper alignment which causes wobble and excessive tire wear.

Firestone pioneered the one-piece tubeless truck tire rim—and to eliminate wobble in demountable rims, Firestone developed the exclusive Open-Face Mounting Ring that's precision-engineered to lock the rim and wheel tightly together in perfect alignment. No other rim design gives you this positive locked-in alignment every time!



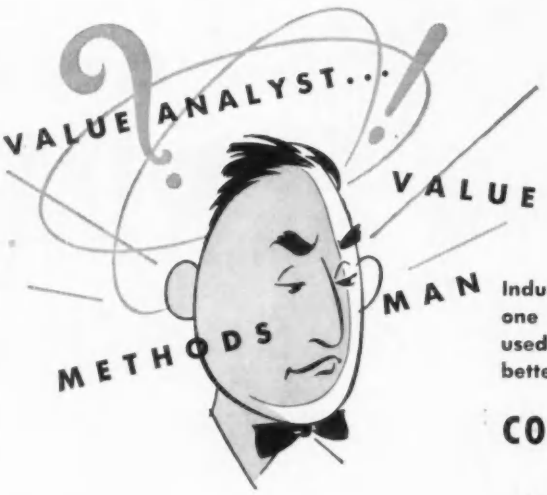
for further information, see your Firestone Rim Distributor or contact

FIRESTONE STEEL PRODUCTS CO.

AKRON 1, OHIO

THE SURPRISINGLY VERSATILE

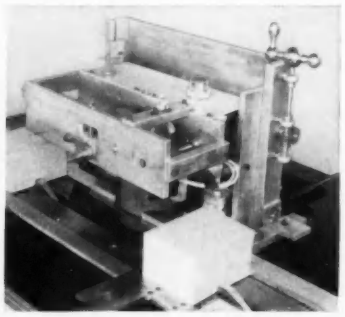
HEIM *Unibal*



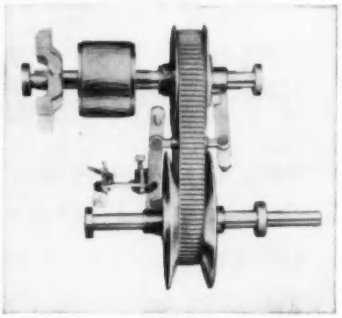
Industry's newest specialist has many names, but just one purpose — to study parts, materials, or methods used in manufacturing, with an eye toward getting better quality or performance at lower cost.

CONSIDER the possibilities of unusual adaptations of the . . . HEIM *Unibal* SPHERICAL BEARING ROD END

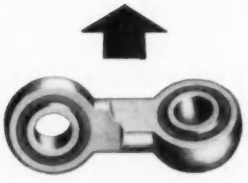
IDEA On the Van Buskirk marking machine, there is a crank, shaft, worm gear, and pinion for raising and lowering printing drums. As an easy-to-install support for this shaft, three Heim Unibal Rod Ends were attached to the frame by simply drilling holes and fastening from the back with ordinary hex-head bolts. While the self-aligning feature of Heim Unibal was not essential at this point, the low cost and simplicity of the mounting made them ideal for these supports.



IDEA Put 2 Heim Unibals in a double-end offset link, such as was done in the Sterling "Speed-Trol" Vertical Mounted electric motor, and you have a smoother operation than could be obtained with specially machined, high cost part and without resorting to weldments or other time- or labor-consuming operations. This double end construction is not a stock item to be sure, but it demonstrates the possibilities of improved operation with the Heim Unibal.



There are no set rules to say that a rod end can only be used as a bearing at the end of a push-pull rod — consider the versatility of the Heim Unibal, whose applications are practically unlimited.



MALE AND FEMALE SIZES ARE LISTED IN THE COMPLETE CATALOG OF HEIM BEARINGS.

THE HEIM COMPANY
FAIRFIELD, CONNECTICUT

HAS MANY USES OTHER THAN STRICTLY ROD END APPLICATIONS

HERE ARE 44 OF AVIATION'S MOST PRODUCTIVE ACRES

Ryan is a $30 million facility, superbly equipped for its job of serving the aircraft and engine industries and the military services. With 850,000 square feet of factory floor space, Ryan manufacturing includes "big" jobs like the huge Boeing KC-135 mid and aft fuselages and Douglas DC-8 jet engine pods and pylons. With the most modern machine tools for forming, welding, machining and heat treating, Ryan manufactures the exacting jet engine, afterburner, rocket and ramjet components which require surgeon-like skills and intimate knowledge of high temperature alloys.

Ryan is 4750 people, headed by a management that has demonstrated experience and vigor in achieving top performance in quality, delivery and low costs. Ryan's financial stability and sound growth are widely recognized. Ryan's skilled production people are specialists who draw upon a background that covers 33 years of the half-century of flight. There is no parallel to the Ryan combination of experience, facilities and proven performance in its fields.

Ryan is a leader in research and development, which believes in "never letting well enough alone." One out of every six employees is in the engineering division. By enlightened attack upon aviation's complex problems, Ryan engineers are continually advancing the state of the art. Significant milestones in this steady progress are Ryan's all-jet VTO airplane, the world's first; the Firebee jet target drone and Ryan's unique electronic systems for automatic, global navigation and for missile guidance.

With a background of 33 years of experience in aviation, Ryan excels in designing and producing high quality aircraft, power plants and avionics, built at low cost, delivered on time.

Engineers looking for a challenging future will find outstanding opportunities at Ryan.

RYAN
AERONAUTICAL COMPANY
SAN DIEGO 12, CALIFORNIA

in a new car . . .
in a used car . . .

stainless steel sells and re-sells

The Stainless Steel trim, molding and vital parts that add style and beauty to a car, inside and out, are features that help make the sale.

Stainless Steel has wide customer acceptance. It's easy to clean and keep clean. It's a tough, solid metal that will not corrode or dent and stands up to gravel, ice, salt and water.

The finish never fades and parts are easy to replace. Stainless Steel lasts the life of the car. It *sells* in a new car and it *re-sells* in a used car.

McLOUTH STAINLESS STEEL

for automobiles

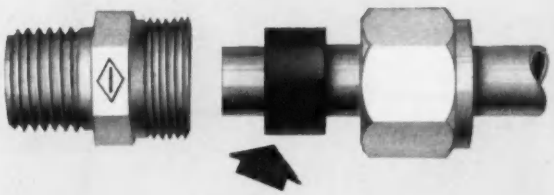
McLOUTH STEEL CORPORATION
Detroit, Michigan

Manufacturers of Stainless and Carbon Steels

The Fitting that Never Gets Tired of Absorbing Shocks and Vibration!

IMPERIAL FLEX FITTINGS

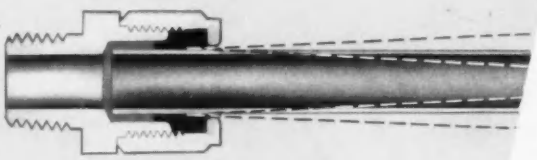
. . . Make Tube Fitting Failures Unnecessary



Every Flex Fitting embodies this vibration and shock absorbing sleeve.

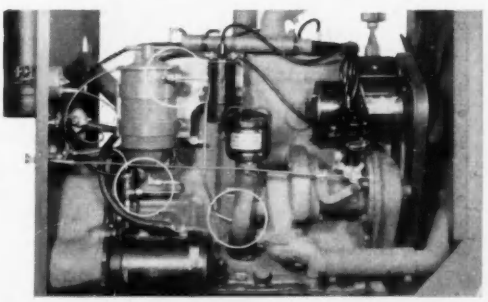
FLEX FITTINGS make safer joints that are virtually indestructible by vibration . . . absorb shock and minor tube movement . . . assure a positive pressure-tight seal.

FLEX FITTINGS are very easy to install . . . simply slip nut and Flex sleeve over tubing . . . insert tubing into body and tighten nut — that's all!



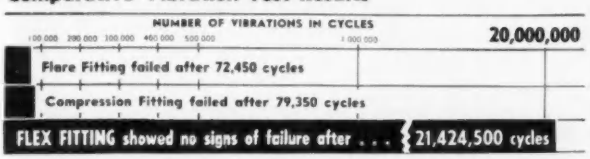
The Flex Fitting actually permits the tube to flex back and forth through angle shown. Note that tubing is cushioned against any damage.

FLEX FITTINGS can be used with all kinds of tubing



If you have a tough tubing connection job that involves vibration, shock or tube movement, it will pay you to consider IMPERIAL FLEX FITTINGS. Whether it's tractors, diesels, heavy power equipment, machinery or earth movers, you will be safe with FLEX FITTINGS. Thoroughly proved by extensive use.

Comparative Vibration Test Results


NUMBER OF VIBRATIONS IN CYCLES
100,000 200,000 300,000 400,000 500,000 1,000,000
20,000,000
Flare Fitting failed after 72,450 cycles
Compression Fitting failed after 79,350 cycles
FLEX FITTING showed no signs of failure after . . . 21,424,500 cycles

On vibration tests, where other fittings failed quickly, Flex Fittings withstood over 20,000,000 cycles without sign of failure.

Ask for Catalog 344

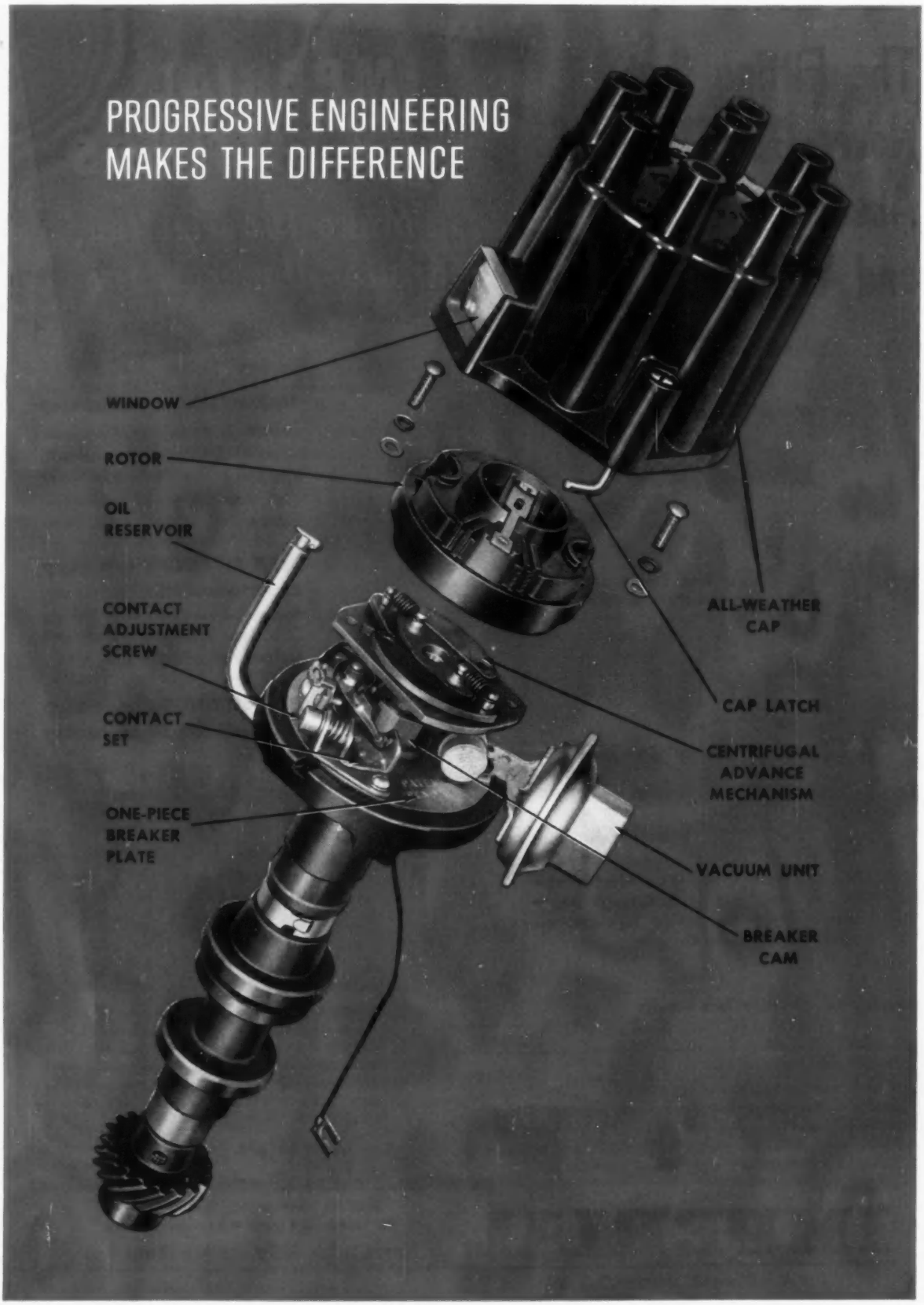
THE IMPERIAL BRASS MANUFACTURING COMPANY

1225 W. Harrison St., Chicago 7, Ill.

In Canada: 334 Lauder Ave., Toronto, Ontario

IMPERIAL

Pioneers in Tube Fittings and Tube Working Tools


PROGRESSIVE ENGINEERING
MAKES THE DIFFERENCE
WINDOW
ROTOR
OIL
RESERVOIR
CONTACT
ADJUSTMENT
SCREW
CONTACT
SET
ONE-PIECE
BREAKER
PLATE
ALL-WEATHER
CAP
CAP LATCH
CENTRIFUGAL
ADVANCE
MECHANISM
VACUUM UNIT
BREAKER
CAM

DELCO-REMY DEVELOPS REVOLUTIONARY NEW EXTERNAL ADJUSTMENT DISTRIBUTOR

Designed especially for *present* and *future* high-compression engines, Delco-Remy's trend-setting new external adjustment distributor increases timing accuracy, provides greater electrical efficiency and durability combined with unprecedented ease of servicing.

Contact point opening (and hence cam angle) is adjustable through a "window" in the cap *while the engine is running.* No special tool is required—just a simple "hex" wrench. The contact point set is a unit completely assembled and adjusted before being attached to the breaker plate . . . is easy to replace, in servicing, with a new factory-adjusted set, simply by removing two attaching screws.

Centrifugal advance components have been relocated to a position *above* the circuit breaker mechanism, making it possible to locate the high-rate-of-break cam and the high speed breaker lever directly adjacent to the main bearing, for maximum rotational stability. The new one-piece circuit breaker plate rotates about the upper main bearing on a precision-fit bearing surface concentric with the shaft. Because of this new low-friction, concentric-rotating breaker plate, vacuum advance performance and hence fuel economy, are improved.

The new all-weather cap is easy to remove and replace—even in crowded underhood areas—by simply turning the spring loaded latches with a screwdriver. Removal of the cap completely exposes the entire distributor mechanism for easy access.

This all-new design in ignition distributors is another example of Delco-Remy leadership "Wherever Wheels Turn or Propellers Spin."

DELCO-REMY • DIVISION OF GENERAL MOTORS • ANDERSON, INDIANA

GM GENERAL MOTORS

GENERAL MOTORS LEADS THE WAY—STARTING WITH

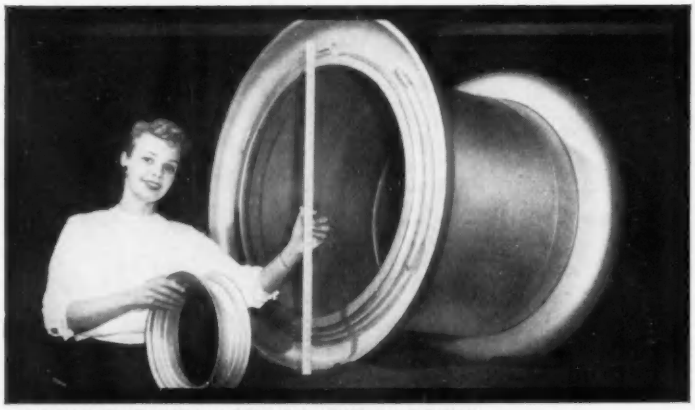
Delco-Remy

ELECTRICAL SYSTEMS

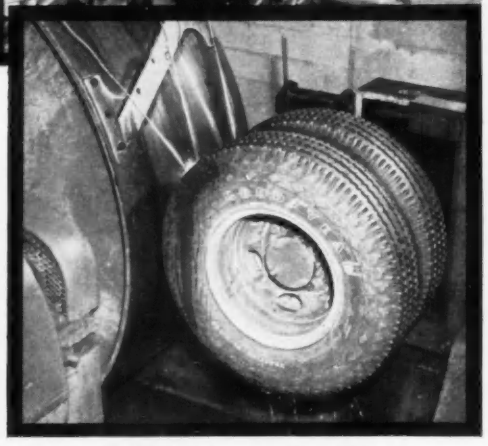
FROM THE WORLD'S LARGEST

World's most com

Goodyear stores rims in outdoor areas, and so can you—thanks to exclusive Goodyear Bond-a-Coat finish which provides long-lasting resistance to rust and corrosion. Bond-a-Coat has been used and proved on Goodyear Rims for ten years.



FROM THE SMALLEST TO THE LARGEST — THERE'S A GOODYEAR RIM TO FIT YOUR NEEDS



Truck, Bus and Trailer Rims must best this test. Rim and wheel assemblies travel the equivalent of 750,000 miles in 30 days on this unique apparatus. It's a testing drum on which obstacles, mounted at intervals, simulate severest road conditions. Only when a Goodyear rim passes tests like these is it ready to be manufactured in quantity.

TIRE MANUFACTURER COMES THE

plete line of rims

YOU'D naturally expect the world's tire-building leader to be first through the years in the advancement of tire-mounting techniques.

So from Goodyear's huge research and testing facilities has come a never-ending parade of rim improvements—culminating in a complete line of rims for tubeless tires – including the Tru-Seal Rim, which makes tubeless tires practical for even the largest vehicles used today.

What does this notable record of achievement mean to you? Just this.

Whatever your rim requirements, you'll find the answer emerging from Goodyear's modern steel fabricating plant.

This busy plant turns out rims for every type of vehicle, from the smallest truck to the largest earth-mover—for every imaginable farm and industrial use. These rims range in weight from 8 pounds to over half a ton.

And each type is subjected to the most grueling tests of quality and endurance before being approved or recommended.

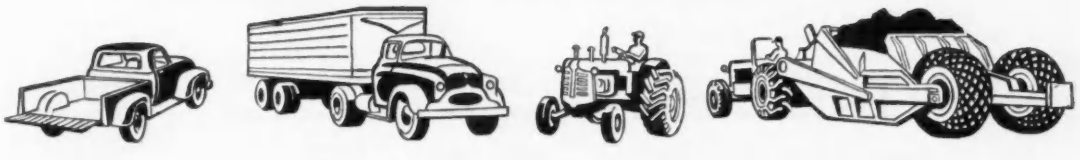
So it's not surprising that more tons are carried on Goodyear rims than on any other kind. Why not take advantage of this vast Goodyear experience when solving your rim problems. The G.R.E. (Goodyear Rim Engineer) will help you select the type and size of rim best suited to your needs. Write him at Goodyear, Metal Products Division, Akron 16, Ohio, or contact your local Goodyear Rim Distributor.

Buy and Specify

GOODYEAR

Tru-Seal—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

MORE TONS ARE CARRIED ON GOODYEAR RIMS THAN ON ANY OTHER KIND



When you demand high uniform quality, *you use Bonderite under the paint.*

PROTECTED BY Bonderite PARKER RUST PROOF CO. QUALITY CORROSION RESISTANT

SEAL WITH A MEANING

The red and silver Bonderite seal on your products will tell buyers, "This Product Will Look Better Longer," 25 years of national advertising backs up this seal. Write to find out how you can cash in on it.

● When you see the smooth, tight-grained, uniform Bonderite coating move past the inspection station, you know your final paint film will be smooth, even and lustrous.

There's another point to mention here. As production men know, when inspection finds high uniform quality on the paint line, there'll be mighty few field refinishing costs to bite into profits.

High uniform quality is just one of the advantages Bonderite delivers. Let us tell you the rest of the story. Write or call today.

**Bonderite, Bonderlube, Parco, Parco Lubrite, Parker Pre-Namel—Reg. U.S. Pat. Off.*

PARKER RUST PROOF COMPANY
2181 E. MILWAUKEE, DETROIT 11, MICHIGAN

Since 1914— leader in the field

BONDERITE corrosion resistant paint base

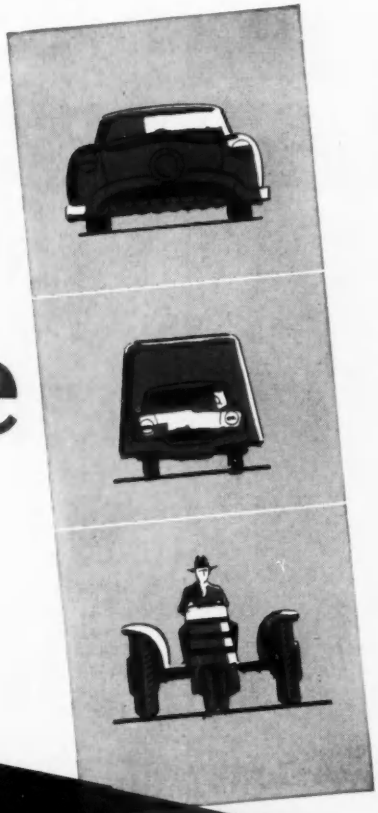
BONDERITE and BONDERLUBE aids in cold forming of metals

PARCO COMPOUND rust resistant

PARCO LUBRITE wear resistant for friction surfaces

TROPICAL heavy duty maintenance paints since 1883

first choice



for modern cars, trucks and tractors

"No Kick-Out" feature combines new starting efficiency with proven economy

• Higher compression ratios, lighter flywheels and other advancements in modern engines have long pointed up the need of a starter drive that would follow through the weak explosions until the engine actually runs on its own power.

That's why vehicle manufacturers are turning in ever increasing numbers to the Bendix* Folo-Thru Drive as the solution to quicker and more dependable starting even under most adverse conditions.

This preference for the Bendix Folo-Thru Drive on modern vehicles is a most logical one, for Bendix Drives have always been the industry's choice as the most economical and efficient starting equipment.

*REG. U. S. PAT. OFF.

ECLIPSE MACHINE DIVISION of

Bendix
AVIATION CORPORATION

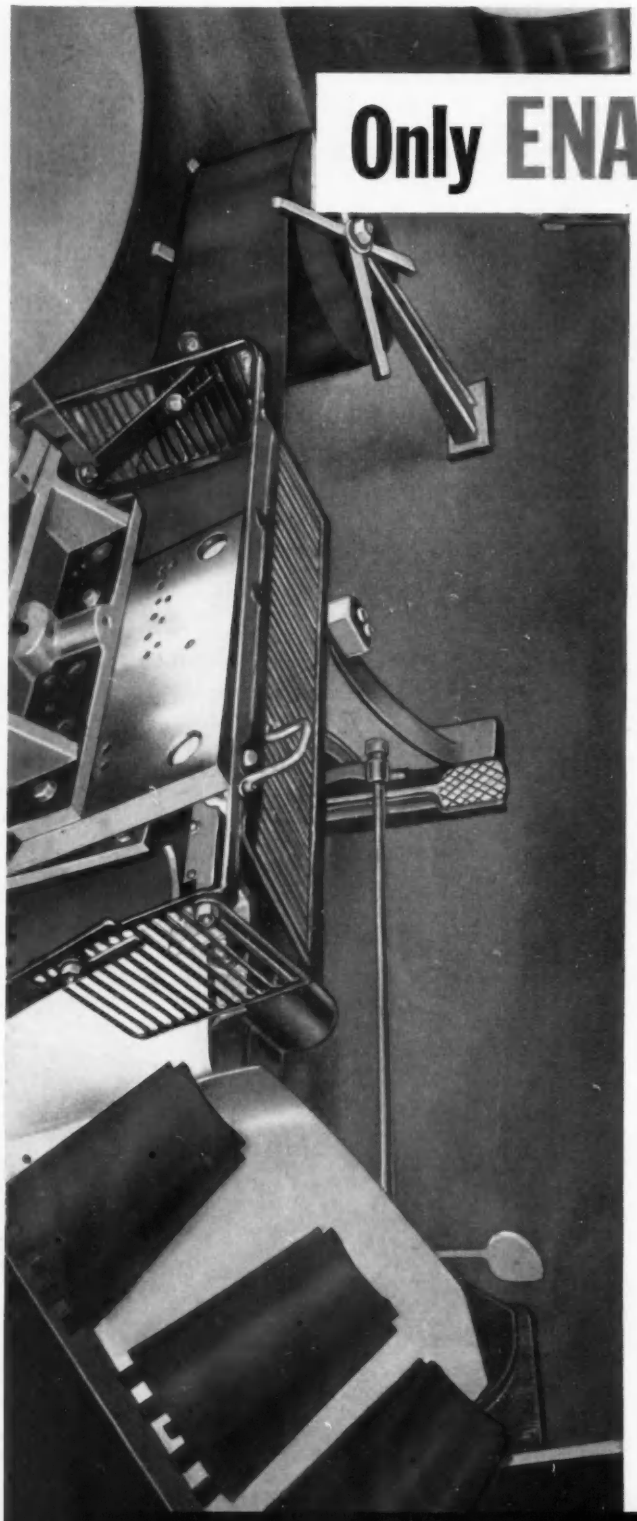
ELMIRA, NEW YORK

Export Sales: Bendix International Division, 205 East 42nd St., New York 17, N. Y.

Bendix folo-thru starter drive

costs less. *Like the more than 95,000,000 Bendix* Starter Drives manufactured for the industry, the new Folo-Thru Drive requires no actuating linkage and the solenoid may be placed in any convenient position. Result is lower installation costs and no adjustments. Complete detailed information is available on request.*

Bendix* Folo-Thru Starter Drive Bendix* Automotive Electric Fuel Pump Stromberg* Carburetor



Only ENAMELSTRIP gives CERTIFIED by the

These are just 7 of the basic tests on which Enamelstrip has been granted Certification. Special tests are added as uses are encountered which require individual considerations.

FLEXIBILITY

A test to determine the capacity of Enamelstrip coated surfaces to withstand the bending and shaping in normal manufacturing operations without cracking. This is an important *quality control* feature for manufacturers. Flexibility tests were run under normal temperature, as well as under conditions of high temperature and high humidity.

SALT SPRAY

This test duplicates the action of normal corrosive elements in the atmosphere; it is also useful in determining the effect of sea water exposure on the surface tested. It is important wherever the end-use product is to be used near swimming pools, beaches, or in general outdoor applications. Especially important for valuable equipment such as portable radios, cameras, etc.

Enamelstrip pre-coated metal coil is pre-tested and certified for performance – your assurance that it will not only withstand the rigors of your production – but also meet or exceed the special end-use requirements of the product you are manufacturing.

Enamelstrip takes the guesswork out of your bending, drawing, forming, piercing, blanking and stamping operations. It makes it possible for you to get all the economy and added production advantages that are made possible by continuous pre-coated metal coil, with the added assurance of continuous quality. The pre-tested quality of Enamelstrip enables you to set and maintain your product's performance standards at a pre-planned level.

Enamelstrip is available in a variety of metals and finishes, and is now being produced in the following base metals: cold rolled steel, tin mill black plate, electrolytic tin plate, electro-galvanized steel, aluminum, brass, copper, and zinc. Our accurate custom slitting operation makes it possible for us to furnish you with Enamelstrip in widths ranging from 7/32″ to 32″. Enamelstrip can be made available in all gauges ranging from .005 to .035 (and heavier in aluminum).

Exacting and continuous control of the oven baked coatings applied makes possible the continuous quality and end-use

CONTINUOUS PRE-COATED ENAMELSTRIP

you PRE-COATED METAL COIL for end-use PERFORMANCE

UNITED STATES TESTING CO.

SCRATCH HARDNESS

This test determines how well the coating will withstand contact with pointed or sharp objects. It covers such conditions as the action of sand against awnings at the seashore. Surfaces that lack sufficient scratch hardness mar easily, exposing the under metal to corrosion after scratching.

ACCELERATED WEATHERING TEST

A vital test for products in outdoor use, such as lawn furniture, outdoor play equipment, etc. It exposes the product to the action of light and water over a period of hours to determine its resistance to these elements. Findings are judged against Federal specifications. This test does not consider the effect of low or high temperatures.

ABRASION RESISTANCE

This test determines the resistance of the coating to rubbing or continual contact with another object. This is an important consideration where the material is to be used for products with moving parts (such as lids, sliding curtain rods, etc.), and in products which are portable (such as flashlight cases, and various household articles).

IMPACT RESISTANCE

A test to determine the resistance of the coating to sudden impact and strain which occur during normal manufacturing operations, as well as in various end-uses. This quality is important in toys, for instance, which usually must withstand abuses such as dropping, kicking, etc. If a coating is too brittle, a sudden impact may cause it to break and flake away from the base metal.

ADHESION

A test to determine the adherence of the coating to the base metal. Adherence must be firm and lasting, so that the coating will not lift away from the metal either during shaping or forming operations, or in consumer use. Long lasting adhesion is important in quality products, (especially those which undergo severe forming operations in manufacture, are subsequently subject to considerable handling, and which may be classified as "permanent" installations such as drapery hardware or air conditioning units).

performance certified to by the United States Testing Company. All organic coatings including alkyds, vinyls, epoxies, phenolics, oleoresinous and many other types of enamels and lacquers are applied. Dry film thicknesses are completely and uniformly controllable to within .0001 and are applied in accordance with end-use requirements. *Enamelstrip continuous pre-coated coil may be coated on one or both sides, either with the same or with different types of finishes and/or colors.* Variegated surface effects may be obtained by the use of Enamelstrip's newly developed "LITHO" finishes.

Let us show you how Enamelstrip quality coil can give you a better, more economical, more profitable operation and more predictable results than ever before. Our representative will call on request.

VINYL LAMINATES

Having pioneered in the development of pre-coated metal coil, Enamelstrip is again leading in the development of organic-clad metal coil. Plastic-metal laminate which can be formed, drawn or stamped is available in a large variety of colors, embossings and as many as four color prints. This new product pioneered by Enamelstrip opens new opportunities for the use of continuous coil in high speed automated production.

The MEANING of
United States Testing Company
CERTIFIED QUALITY

To determine the exact quality of Enamelstrip pre-coated metals, the United States Testing Company took random samples of Enamelstrip production – subjected these samples to impartial tests – and evaluated them on the basis of the following considerations:

1. *The quality of Enamelstrip compared with the quality of competitive products.*
2. *The actual performance of each Enamelstrip metal: on the basis of manufacturer's needs in production, and consumer needs in end-use applications.*

In all cases, the quality of the Enamelstrip pre-coated metals proved to be equal to or better than the competitive products tested. The Enamelstrip metals also were found to satisfactorily meet and in most cases exceed the production requirements of the manufacturer and the end-use requirements of the consumer. On the basis of these findings, the United States Testing Company has granted the Seal of Certified quality to Enamelstrip. The United States Testing Company will continue to check-test Enamelstrip pre-coated coil, as part of Enamelstrip's continuing certified quality control program.

Sold by **COATED COIL CORPORATION**
501 West 30th Street, New York 1, N. Y. • LOngacre 5-3161

Boyertown bodies of Mayari R offer "more strength, per pound, per dollar"

Boyertown Auto Body Works, of Boyertown, Pa., is a long-time builder of vehicular bodies, and its line of walk-in delivery units is among the largest. One of the secrets of Boyertown's success rests in the belief that there is always a "better way to build a better body."

In that atmosphere, Boyertown's selection of Mayari R high-strength, low-alloy steel was a natural. Because Mayari R's yield point is 50 pct greater than that of carbon steel, Boyertown engineers used it for side panels and key structural members to turn out a rugged design, while cutting overall body weight by 25 to 40 pct.

This, in turn, gave the sales people a highly promotable product which offers "more strength, per pound, per dollar." In the tough stop-and-go service to which walk-ins are subjected, this kind of talk is making good sense to more and more buyers.

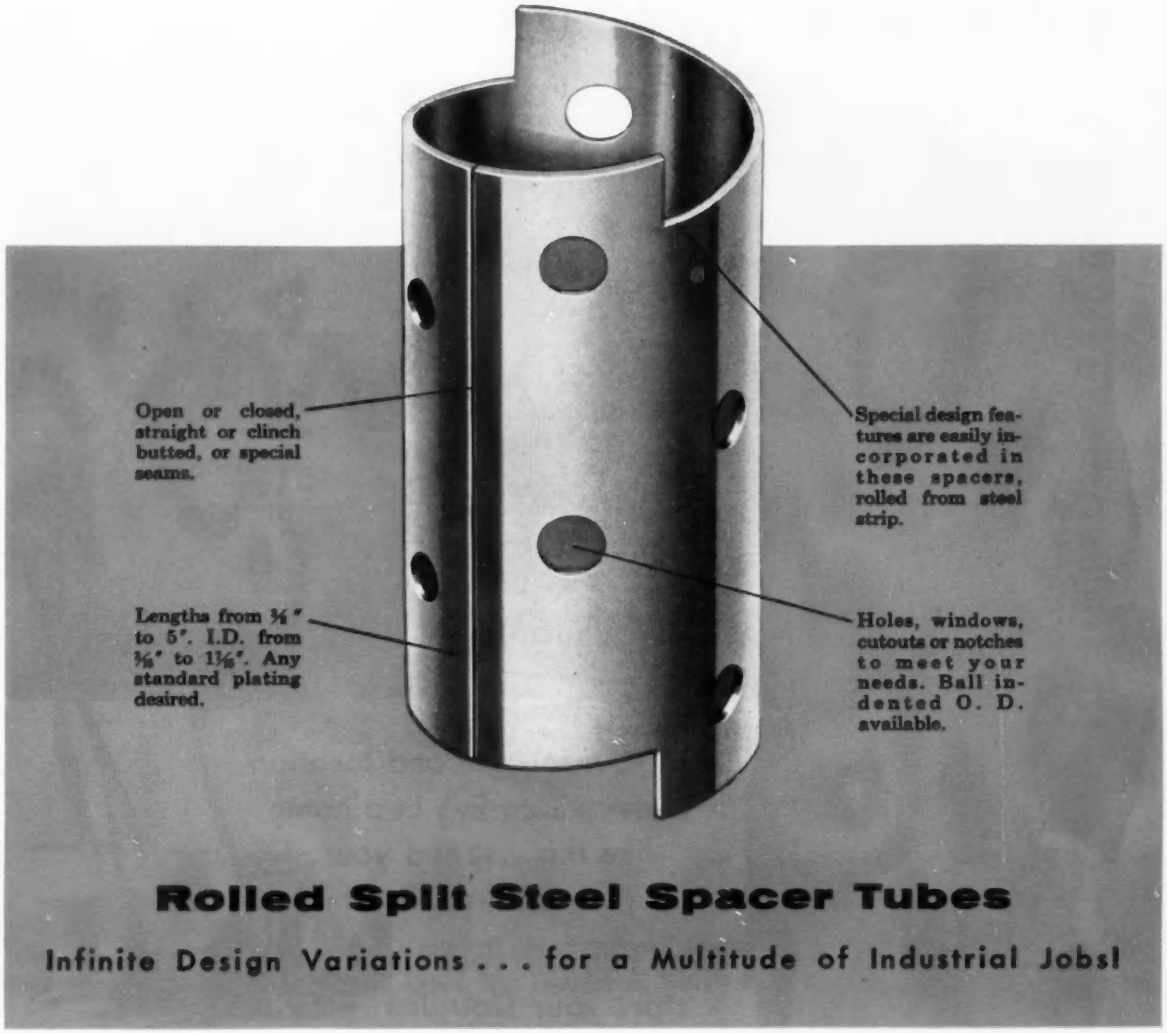
Boyertown customers also appreciate Mayari R's resistance to atmospheric corrosion, which is 5 to 6 times that of plain carbon steel. And when it comes to handling in the shop, Mayari R is just about as easy to weld, form, flame-cut and machine as plain carbon steel.

You'll find a comprehensive picture of Mayari R, and the potential it holds for you, in the pages of Catalog 353. You can get a copy through any Bethlehem district office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

Mayari R...High-Strength, Corrosion-Resisting Steel


Open or closed, straight or clinch butted, or special seams.
Lengths from ⅜" to 5'. I.D. from ⅜" to 1⅛". Any standard plating desired.
Special design features are easily incorporated in these spacers, rolled from steel strip.
Holes, windows, cutouts or notches to meet your needs. Ball indented O. D. available.

Rolled Split Steel Spacer Tubes

Infinite Design Variations . . . for a Multitude of Industrial Jobs!

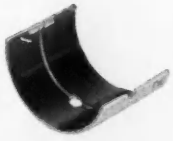
Delivered ready for assembly—no costly cut-off or de-burring. Save the cost of pipe or tubing. No scrap or material handling or inventory! You can save purchasing time, too—645 standard lengths, diameters and gauges. Special designs available. Send for free catalog and price list.

FEDERAL-MOGUL
DIVISION, Federal-Mogul-Bower Bearings, Inc.
11035 Shoemaker, Detroit 13, Michigan

BEARING-SURFACED THRUST WASHERS

BABBITT-LINED BEARINGS

PLAIN & BIMETAL SPLIT BUSHINGS


COPPER-LEAD BEARINGS

FEDERAL Mogul
SINCE 1899

RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

ENGINEERS...LOOK TEN YEARS AHEAD!

A Douglas engineer lives here

Will your income and location allow you to live in a home like this...spend your leisure time like this?

They can...if you start your Douglas career now!

Your objectives are probably high professional standing, good income, good security and good living. All four can be achieved at Douglas.

Douglas has the reputation of being an "engineer's outfit," with the three top administrative posts being held by engineers. Maybe that's why it's the biggest, most successful unit in its field. Certainly it offers the engineer unexcelled opportunities in the specialty of *his* choice ...be it related to missiles or commercial or military aircraft.

You've looked around. Now look ahead... and contact Douglas.

For further information about opportunities with Douglas in Santa Monica, El Segundo and Long Beach, California and Tulsa, Oklahoma, write today to:

DOUGLAS AIRCRAFT COMPANY, INC.
C. C. LaVene, 3000 Ocean Park Boulevard, Santa Monica, California

DOUGLAS

First in Aviation

STRAIN

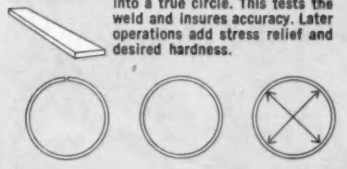
can halt your customers' payloads when rims don't give top performance. Stop complaints. Specify Cleve-Weld as your primary rim source.

Cleve-weld rims are designed six ways better!

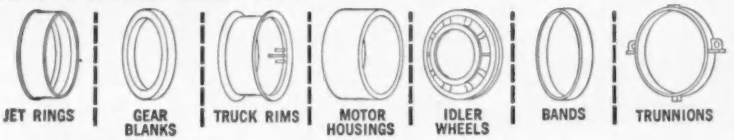
1. Rim thickened at strategic points... increases resistance to severe stresses.
2. Tapered beads on both sides of rim ...tire mates firmly with the rim.
3. 28° mounting bevel...enables rim to be mounted on all cast wheels.
4. Lightweight construction...means higher payloads for customers without loss of strength.
5. Tire rests on tapered bead seat...tire stays put when puncture occurs.
6. Designed for any brand or type of tire...flexibility ends tire replacement problems.

For 45 years Cleve-Weld has specialized in rolled and welded circular products...good reason why *you save when you specify Cleve-Weld as your primary source for all rolled and welded circular parts.* We'd like to talk it over. Write Circular Welded Products Sales Department at address below.

THIS IS THE BASIC CLEVE-WELD PROCESS. Rectangular bars or special contoured sections of steel are rolled into a circular form. Next, the part is welded and then expanded into a true circle. This tests the weld and insures accuracy. Later operations add stress relief and desired hardness.



EXAMPLES OF CLEVE-WELD PROCESS PRODUCTS



Another AMF Product

CLEVE-WELD PROCESS
RIMS · RINGS · WELDMENTS

CLEVELAND WELDING DIVISION
AMERICAN MACHINE & FOUNDRY COMPANY
Cleveland 7, Ohio

SEND THIS COUPON NOW

Cleveland Welding Division
American Machine & Foundry Company
West 117th Street and Berea Road
Cleveland 7, Ohio

Please send me:

- ☐ Truck Rim Catalog
- ☐ Tractor Rim Catalog
- ☐ Brochure on Cleve-Weld Process

Name_____

Title_____

Attach to your company letterhead and mail

NOW! *A new tool for the application of automotive power...*

THE NEW TDA® WIDE

We "Flipped Our Helicals" So We Could Widen the Range!

The broader range of the new Timken-Detroit® WIDE RANGE 2-Speed Axle was achieved by an ingenious mechanical rearrangement. We "flipped" our high-range (1) and low-range (2) helical gear sets—reversed their relative positions—to place the enlarged helical pinion of the high-range gear set where it would not interfere with the hypoid pinion (3) of the first-reduction gear set.

RANGE®

2-SPEED AXLE

for all operations requiring short transmission steps and high overall gear reduction

The new TDA WIDE RANGE 2-Speed Axle brings a new concept of flexibility and driving simplicity to the automotive industry. It offers all the highly desirable advantages heretofore available only through the use of complex multiple-speed transmissions or auxiliary gear boxes *without* many of the penalties of one or the other:

WITHOUT laborious two-stick shifting.

WITHOUT wasteful excessive weight.

WITHOUT increased driver fatigue.

WITHOUT unusual wheelbase limitations.

WITHOUT higher initial vehicle cost.

WITHOUT higher maintenance cost.

WITHOUT excessive wear on the lower speed gears of the transmission.

WITHOUT restricted over-all gear reduction.

WITHOUT complicated shift patterns.

This is but a brief summary of the many distinct, positive, provable advantages afforded by the development of this new WIDE RANGE concept in the famous TDA line of double reduction two-speed axles. For complete information on the new TDA WIDE RANGE Axles now available (in both 2 to 1 and 2½ to 1 ratio spreads) call, wire or write your nearest vehicle dealer or branch.

©1956, R S & A Company

TIMKEN Detroit AXLES

TIMKEN-DETROIT AXLE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
DETROIT 32, MICHIGAN

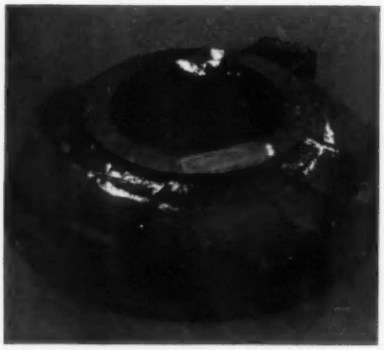
The Accepted DA Standard
TRADE MARK REGISTERED

Plants at: Detroit, Michigan
Oshkosh, Wisconsin • Utica, New York
Ashtabula, Kenton and Newark, Ohio
New Castle, Pennsylvania

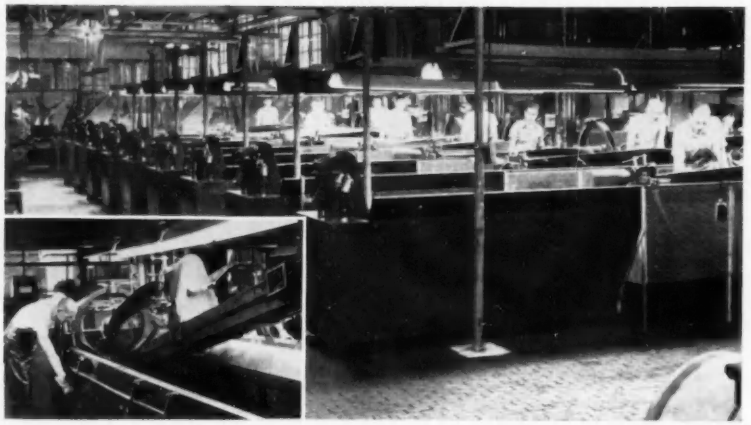
World's Largest Manufacturer of Axles for Trucks, Busses and Trailers

Case Studies:
NONDESTRUCTIVE TESTING SYSTEMS

AUTOMATIC AND HIGH SPEED MAGNAGLO UNIT inspects and processes steam turbine blades. By providing two-directional magnetization at the same time, it reveals cracks in any direction in a single "pass". An ideal method for lower cost, higher speed inspection needs.



INSPECTING MAGNESIUM CASTINGS — Inspection, as such, cannot produce a better product. However, by translating Zyglo indications into corrective measures the foundry can produce castings which meet the needs of their customers. Zyglo fluorescent penetrant inspection detects such flaws as cold shuts, cracks, blows, shrinkage and dross in non-ferrous magnesium or aluminum castings.



Specially designed Magnaflux units tilt for inside-outside inspection of hollow steel propeller blades.

How Lower Production Costs Can Result From "Customized" Testing

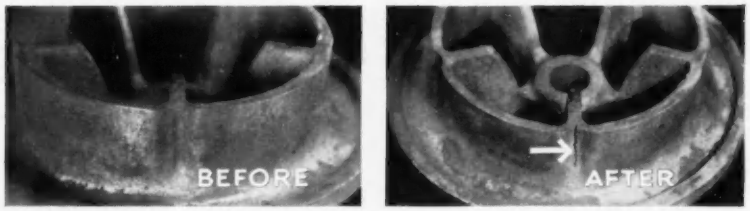
Nobody expects to find defective propeller blades at 20,000 feet. Propeller manufacturers must, and do, discover even the tiniest flaws during manufacture and before their products ever leave the ground. A battery of specially designed Magnaflux units insures defect-free production at the Wright Aero Corp. New Jersey propeller plant.

Of course, you don't make propeller blades. Whatever your product, you can use low cost standard test equipment—or tailor-made production test equipment TO MEET YOUR OWN NEED!

Magnaflux methods detect cracks, seams, porosity and other minute defects during the production process. By evaluating M findings, the proper corrective steps are taken to eliminate early defects. Substantial savings result from increased production, doing away with further processing effort on faulty parts, and from reduced scrap losses.

If you're "up in the air" regarding defects in critical components, Magnaflux builds and sells nondestructive test equipment to meet your exact production-line or sample test needs. Or, if your operation requires only occasional reliable testing, why not investigate our Commercial Inspection Service, available on a low-cost basis in most major industrial communities?

For detailed information regarding either service, write today, or contact one of our nearby offices for a personal get-together with an experienced Magnaflux field engineer.



HOW INVISIBLE FORCE DETECTS MECHANICAL DEFECTS

M nondestructive testing is based upon simple magnetic principles. A part to be tested is first magnetized—then magnetic powders or fluorescent particles in oil are applied. Surface defects cause a break in the magnetic field—local magnetic poles cause particles to be held on part to mark extent of defect. Above—a Magnaflux indication on grey iron casting.

HALLMARK OF QUALITY IN NONDESTRUCTIVE TEST SYSTEMS

Write for complete details concerning any of the above case studies, (excerpts from MAGNAFACTS), or ask for our new booklet on Lower Manufacturing Costs.

Take Your Inspection Problems to the House of Answers . . .

MAGNAFLUX CORPORATION

7348 W. Lawrence Avenue • Chicago 31, Illinois

New York 36 • Pittsburgh 36 • Cleveland 15 • Detroit 11 • Dallas 19 • Los Angeles 58

Let our experience help you

For more than forty years manufacturers in every industry have availed themselves of Bohn's technical skill and fabrication know-how. The benefits of Bohn's wide experience in extrusions, castings and forgings and other fabricated products are available to you. Let us quote on your specifications. Send us your blueprints today!

BOHN ALUMINUM AND BRASS CORPORATION

1400 LAFAYETTE BLDG., DEPT. S
DETROIT 26, MICHIGAN

SALES OFFICES:

Boston • Chicago • Cleveland • Dayton
Detroit • Indianapolis • Milwaukee
Moline • New York • Rochester • St. Louis

BRASS ROD • BRASS AND BRONZE INGOTS • PISTONS • BEARINGS • FORGINGS • EXTRUSIONS • CASTINGS • REFRIGERATION AND AIR CONDITIONING PRODUCTS

WHY ESSO STANDARD

OIL COMPANY

WILL SOON MARKET

THREE GRADES

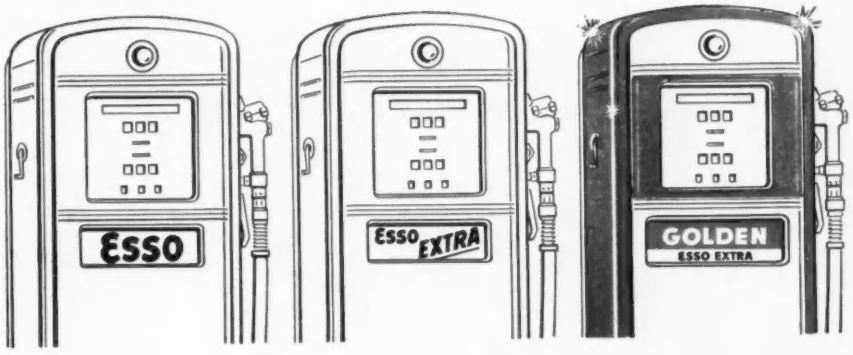
OF GASOLINE

THESE ARE THE FACTS:

No one gasoline can economically satisfy the widening power needs of today's cars.

No two gasolines can give every motorist full value for his gasoline dollar.

Now THREE gasolines, one of which will give each car the right fuel . . . at the most economical price!



SAVINGS OF MILLIONS of dollars for the American motorist are possible through a three-grade system of marketing gasoline. On June 20, our company will begin marketing three grades of gasoline – Esso at "regular" price, Esso Extra the premium grade, and now new Golden Esso Extra, a still higher quality fuel for automobiles with high-compression engines. This new power fuel should be available to 75 per cent of our company's customers by mid-August.

In announcing the higher quality motor fuel, our company moved about four years ahead of schedule. The new gasoline contains power-producing elements of an advanced motor fuel that was originally scheduled for production by Esso in 1960.

Motorists are demanding cars with better performance, and to deliver performance most efficiently, automobile manufacturers have increased compression ratios. These higher ratios demand a higher grade of fuel. Our new gasoline is designed to meet that need.

Traditionally, the petroleum industry has marketed two grades of gasoline – regular and premium. Recently, however, an acute problem arose from the increasingly greater percentage of new cars which are not satisfied by existing premium gasolines.

We decided that merely increasing the octane rating of the current premium grade would be uneconomical to the millions of motorists whose automobiles cannot take full advantage of a higher grade of fuel.

Obviously, if only two grades – regular and a new higher quality premium fuel – were marketed, many motorists would be caught in the middle. The "quality spread" between the two motor fuels would be far too wide.

Both the motorist and the oil industry save when the proper fuel is used in an automobile engine. The three grades system will accommodate all cars, new and old, and save many motoring dollars.

The current regular and premium grades of gasoline are doing an outstanding job for a large percentage of the motoring public and will continue to do so for some years to come. Since higher quality fuel must be made by new processes that are more costly, Esso Standard feels it would be unfair to most motorists at this time to increase the octane and other qualities – and cost – of our present premium fuel.

Esso researchers estimate that the adoption of the three-grade gasoline plan by the American motorist could save the public over half a billion dollars a year in 1961.

We are confident that new Golden Esso Extra, perfected by new refining processes, will deliver the efficiency and mileage intended by the automobile manufacturers when they designed their new engines. And, by marketing three – not two – grades of motor fuel, we will continue to provide the right fuel for every car, and the motorist will not be paying for quality he can't use.

President

ESSO STANDARD OIL COMPANY

R. O. Youngberg (left), Project Department Engineer; J. F. Vinson (center), Designer Engineer, and J. M. Swartz, Structures Design Group Engineer, discuss installation problems associated with a coordinate converter of a new missile electronic system.

MISSILES...THE IDEAL FIELD FOR DESIGNERS

Missile systems design gives Designers the ideal outlet for creative and inventive expression.

Here the Designer works in a growing area where the greatest advances in design are being achieved, an area receiving ever increasing emphasis.

Under Lockheed Missile Systems Division's design policy, Designers receive the broadest possible technical background. Varied assignments, covering structures, controls, hydraulics, pneumatics, electromechanical packaging, fuel systems and related areas, give Designers a thorough grasp of all phases of missile design. Nor is the Designer restricted to conventional approaches in his assignments; new design ideas are welcomed. Moreover, the Designer is kept constantly abreast of the progress of his project.

Through this policy, Designers acquire the technical background so necessary for successful missile design.

Those able to contribute to a design effort of the utmost importance are invited to write. Address inquiries to the Research and Engineering Staff at Van Nuys.

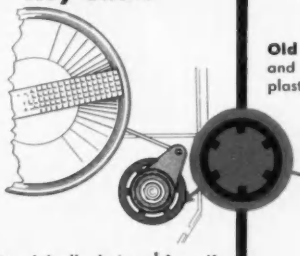
Lockheed **MISSILE SYSTEMS DIVISION** • LOCKHEED AIRCRAFT CORPORATION

VAN NUYS • PALO ALTO • SUNNYVALE • CALIFORNIA

5 Waldes Truarc Rings simplify assembly, eliminate parts, bring big over-all savings to new design low-cost camera

Anscoflex II Camera

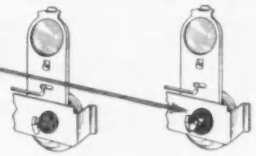
Key Shaft



Parts originally designed for self-locking Truarc ring (series 5105). Some cameras in the past had brass cup staked to the body. At times staking operation cracked the plastic, resulting in loss of expensive part.

Portrait and Filter Lens Knob Assemblies

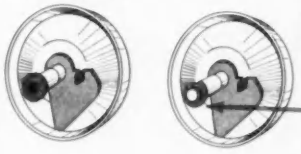
Old way: Knob with plastic shaft used washer and heat forming operation that flattened the plastic pin and locked the pivot in position.



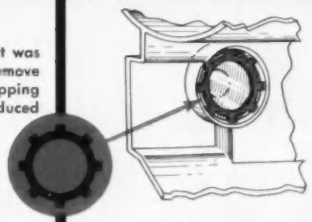
Truarc way: Molded plastic knob with pin is easily and quickly held by a Truarc self-locking ring (series 5105). No groove is necessary. Washer is eliminated and it is possible to remove ring if necessary without damage to knob.

Winding Knob

Old way: With screw and washer design, it was necessary to disassemble entire camera to remove screw which secured winding knob. Self-topping screw sometimes failed to secure knob, produced excessive end play.



Truarc way: Truarc "E" ring (series 5133) allows removal of winding knob without major disassembly of camera, reducing repair time. Use of stacked rings and Truarc applicator saved $10.40 per M on labor. Material saving: $2.29 per M.

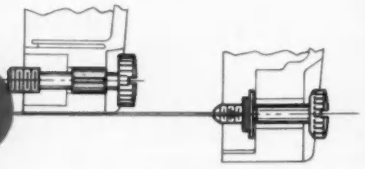


Rear Lens

Parts originally designed for self-locking Truarc ring (series 5005) Some cameras in the past had glass element secured by heat forming tabs from plastic body. Loose or chipped elements resulted in loss of both parts.

Flash-Gun Case Assembly

Old way: In the original design a sleeve was wrapped around neck of screw and pressed into hole of plastic cover. Close working areas made assembly difficult and required extra operation to lock ring into place.



Truarc way: Series 5133 E-Ring snaps onto unthreaded shank of screw quickly, needs no special groove. Labor saving $7.06/M.

Ansco, Binghamton, N. Y., uses the latest technical advances in construction to produce an economical, easy-to-use reflex camera. 5 Waldes Truarc Rings are used in this new design to save material and labor costs, eliminate parts, simplify assembly and reduce rejects.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

For precision internal grooving and undercutting . . .Waldes Truarc Grooving Tool!

Send for new catalog supplement

WALDES

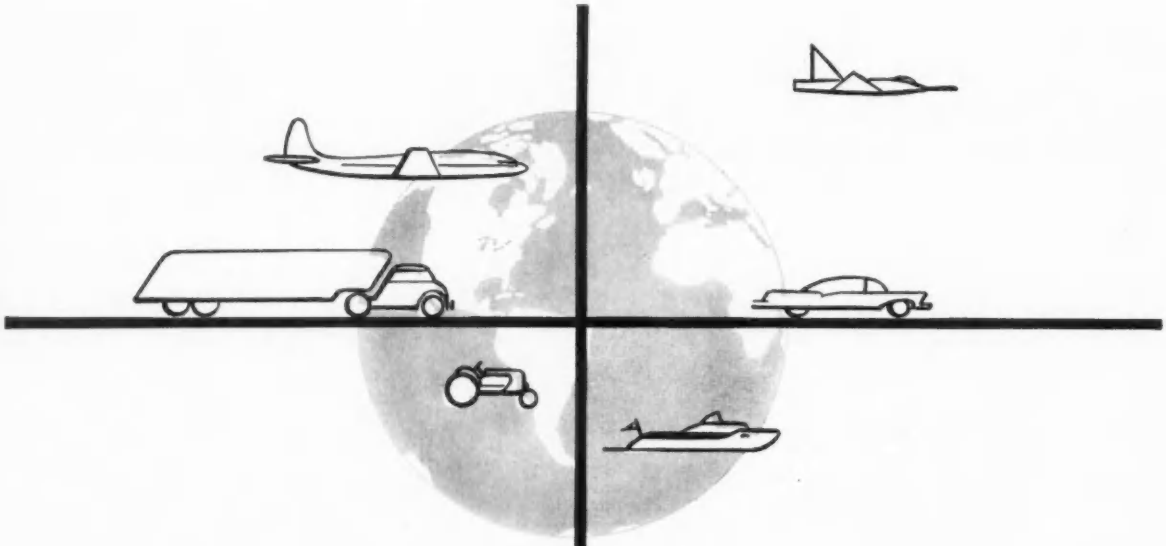
TRUARC®

RETAINING RINGS

Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N. Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
(Please print)

Name.....
Title.....
Company.....
Business Address.....
City..... *Zone*.... *State*.....

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.



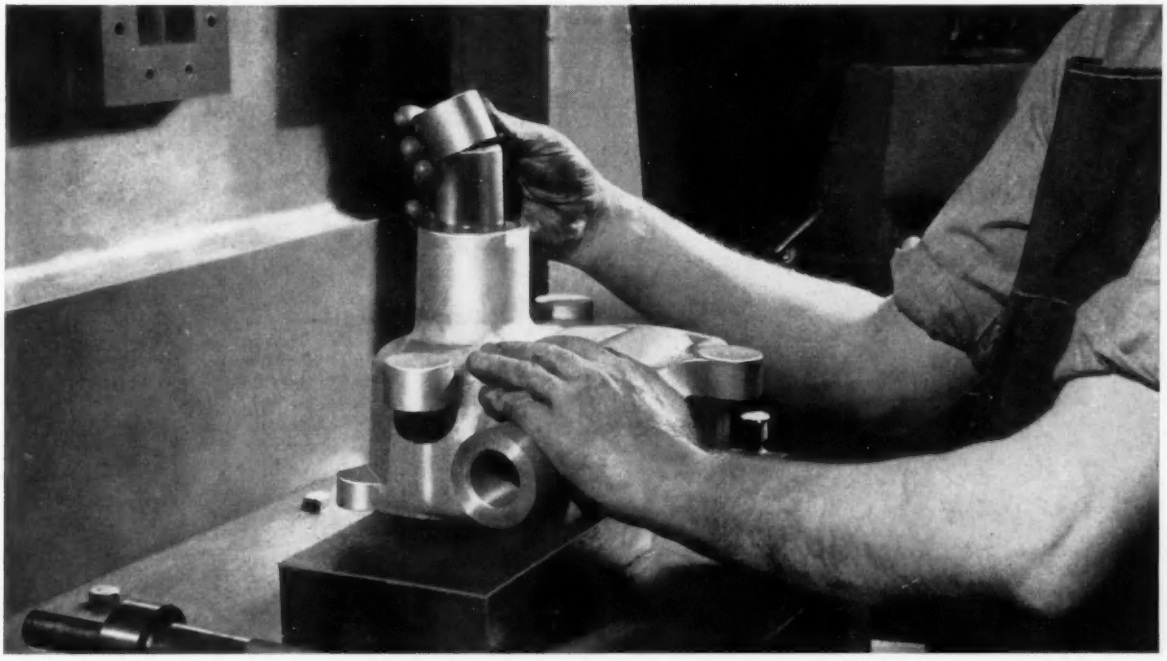
AUTO-LITE | Serves Industry

with more than 400 products of the highest quality

Whether it be intricate die-castings, finely drawn magnet wire, electrical equipment for the automotive industry or any one of hundreds of other products . . . it is of the highest quality when it comes from Auto-Lite. This reputation for quality in 28 plants from Coast to Coast is maintained through central engineering control and is reflected in the public acceptance of the name Auto-Lite . . . and in the world-wide establishment of Auto-Lite service facilities.

THE ELECTRIC AUTO-LITE COMPANY
TOLEDO 1, OHIO

AUTO-LITE



Johnson Quality Bearings and Service Important Components in Gemmer Steering Gears

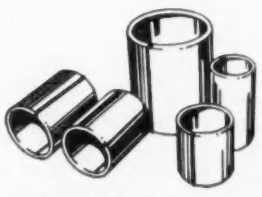
A precision bronze bearing, a little more than one inch long and less than two inches in diameter, is one of the most important components of intricate automotive steering gears according to Gemmer Manufacturing Company of Detroit.

Gemmer produces thousands of power and manual steering gear assemblies for an impressive list of more than fifty automobile, truck, tractor and boat manufacturers each year. Into each go two or three bronze bearings designed to give the steering shaft the greatest possible free-riding movement within the steering gear housing. In fitting the bearing to the shaft a tolerance of only .001 of an inch is permitted.

The greatest portion of these bearings are produced by Johnson Bronze Company of New Castle, Pennsylvania, a major supplier of parts for Gemmer products for more than three decades. Johnson quality, according to George Bissett, Assistant to the Vice President, is one of the reasons for the long association. "Johnson bearings have always worked out perfectly for us," he recalls. "We use thousands of bearings but when we open a box from Johnson we know there will be very few, if any, rejects."

This quality is important in maintaining smooth operations but so is Johnson service, said E. C. McLeod, Gemmer Plant Superintendent. "Delivery has certainly played an important part in our continued use of these bearings. I can't recall a single time when Johnson ever left us flat on our face because of a slow shipment." He points out, "Without these bearings, there would be no steering gears; and without steering gears, there would be very few automobiles produced."

The ability to consistently meet quality and service requirements is one of the reasons why Johnson has wide acceptance in the automotive field—regularly supplies main, cam and rod bearings, and bearings for practically every other component in the modern car, truck or diesel engine made by the industry today. Another reason is the assistance supplied by the Johnson Product Engineering Department which works closely with designers in developing new bearings to meet ever-increasing speeds and loads. To learn more about Johnson quality and service, write Johnson Bronze Company, 675 South Mill Street, New Castle, Pa.



Johnson Bearings

AMPEX PRESENTS

the most significant new data magnetic tape

So broad in scope that it extends the far horizons of scientific and engineering curiosity

Versatility of the Ampex FR-100 permits it to serve virtually any data requirement in the entire D-C to 100,000 cycle/sec. range. Magnetic tape is inherently the most versatile of data-recording mediums and the FR-100 makes broadest use of this scope.

ANY DATA— Within its frequency range, the FR-100 can record any data that either originates in electrical form or can be transduced into electrical signals.

IN ANY COMBINATION — Any numbers of the FR-100's available tracks can be apportioned to high-frequency data, low-frequency data, transient phenomena and quasi-static measurements. Each will use tape space economically. All will share a common time base.

A CHOICE OF RECORDING METHODS — Different types of data are accommodated by plug-in interchangeable amplifiers. These permit each of the FR-100's 2 to 14 tracks to be used for direct recording, FM-carrier recording, or pulse width modulation as needed.

A SELECTION OF 6 TAPE SPEEDS — Every FR-100 tape transport provides tape speeds of 60, 30, 15, $7\frac{1}{2}$, $3\frac{3}{4}$ and $1\frac{7}{8}$ inches per second for optimum balances between recording time and frequency response. They also permit slow-down or speed-up of data in various ratios.

DATA REDUCIBLE TO ANY FORM — The FR-100's output is usable in numerous forms: visual records by oscillograph or pen recorder; visual study by oscilloscope; automatic computation by data conversion devices or computers; and regulation or activation of mechanisms by electrical controls.

THE *modular* FR-100

recorder since Ampex first pioneered for instrumentation

Performance specifications on the FR-100 are the best of any magnetic tape recorder now in production. Such accuracy adds to the FR-100's versatility. It also makes it the best choice for many well defined applications where quality of performance alone is the criteria for selection.

IMPROVED STABILITY OF TAPE MOTION — The closed loop tape drive and short unsupported tape length reduces peak-to-peak flutter to 0.1% cumulative to 100 cycles or 0.2% cumulative to 1000 cycles at 60 in/sec.

PRECISE TRACK-TO-TRACK TIMING — Record and reproduce head stacks permanently aligned with all gaps within a 1/10,000-inch band and azimuth within 0°1'. With FR-100's stable tape motion this provides lowest dynamic interchannel time-displacement error ever available commercially.

"MIL CONSTRUCTION" THROUGHOUT — Mil specification E-4158-A components, hardware and finishes are used throughout.

AMPEX-TO-AMPEX COMPATIBILITY — Recorded data is interchangeable between all Ampex FR-100s, and 300 and 800 series machines (provided tracks are the same type and tape speeds the same).

SIMPLIFIED OPERATIONAL MAINTENANCE — Modular design of the FR-100 reduces most operational maintenance to a simple plug in of spare assemblies with no loss of operating time.

The Ampex FR-100 gives your engineers and scientists a freedom to experiment. In one machine it affords a high portion of all the broadly useful capabilities of magnetic recording. It encourages development of the most effective data recording techniques for your particular specialized needs.

CAPACITY FOR BRILLIANT AFTERTHOUGHTS — The Ampex FR-100 will serve the well defined initial purposes for which it is acquired. But it also provides for the inevitable changes of direction that occur as any research, development or testing program progresses.

AN OVER-ALL ECONOMY — The combined characteristics of the Ampex FR-100 are the equivalent of dozens of different modified tape recorders built by Ampex in past years. One Ampex FR-100 may eliminate need for purchase of a succession of special machines.

For complete description and specifications on the Ampex FR-100, write Dept. K-2750

INSTRUMENTATION DIVISION AMPEX CORPORATION

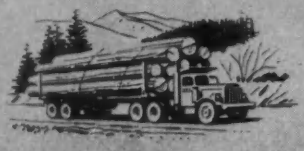
FIRST IN MAGNETIC TAPE INSTRUMENTATION

934 Charter Street • Redwood City, California

District Offices: *Atlanta; Chicago; Dayton; Montclair, New Jersey; Redwood City, California; Silver Spring, Maryland.*

Distributors: *Southwestern Engineering and Equipment Co., Dallas and Houston; Technical Apparatus Co., Boston; Bing Crosby Enterprises, Los Angeles; Ampex-American in Canada.*

The NEW Spicer *Dual-Purpose* 4-Speed Auxiliary Transmissions



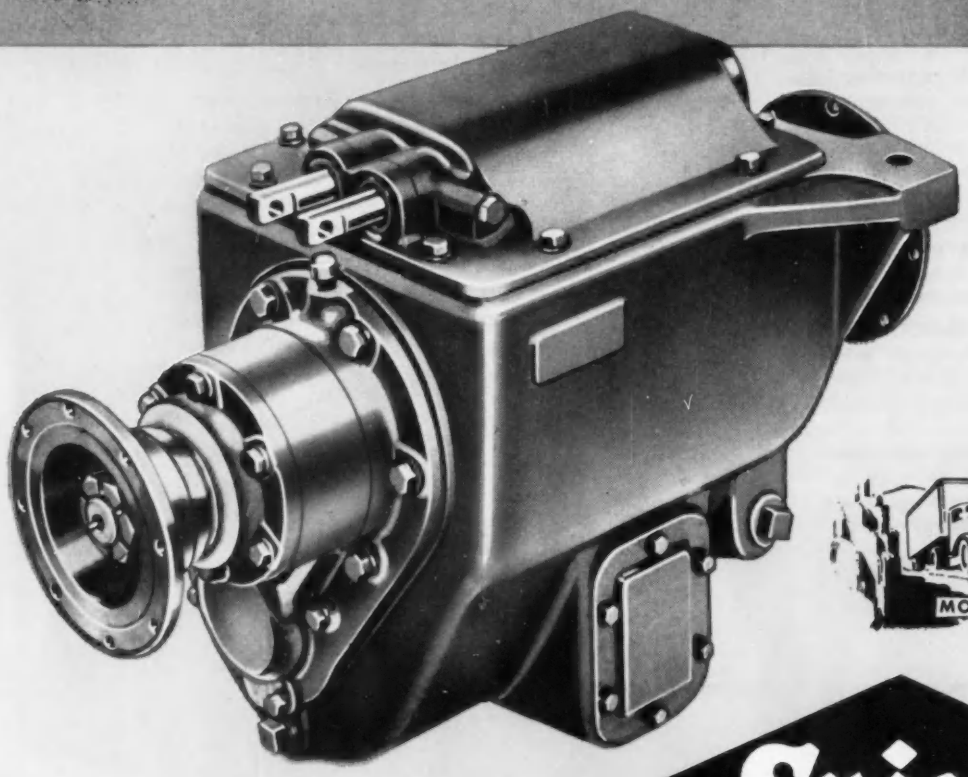
Dual-Purpose:

1. Deep under-drive for *off-the-highway* power

Plus

2. Splitter Ratios for *on-the-highway* speed

—in the same unit!



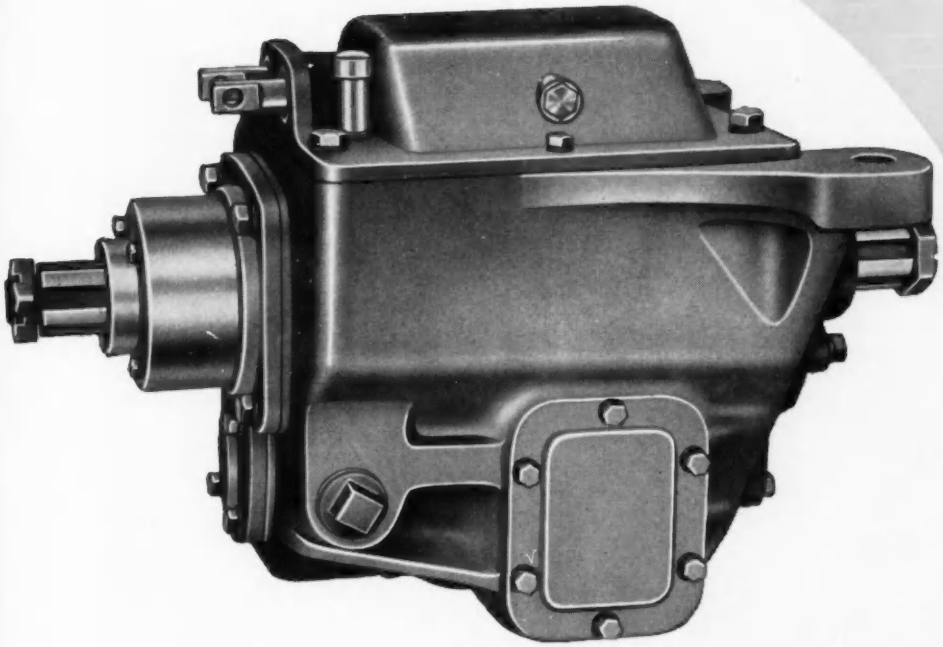
Spicer

DANA CORPORATION • TOLEDO 1, OHIO

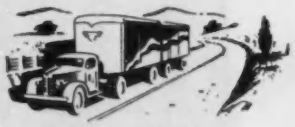
HEAVY LOADS

OPEN ROAD

HILLY COUNTRY



EASIER MANEUVERABILITY



HEAVY HAULING

LIGHT LOADS

Here's another Spicer innovation in auxiliary transmission design for more efficient truck operation . . . a deep underdrive and splitter ratios in *one gear box!*

This means plenty of power for tough operating conditions when *off-the-highway* on any terrain.

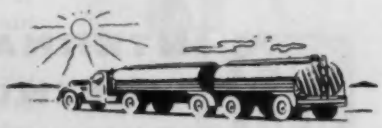
And it means plenty of speed for fast *on-the-highway* operation!

Another important feature: these new Spicer 4-Speed Auxiliaries have exactly the same overall length as Spicer 3-Speed Auxiliaries. They can be installed in the same vehicle without change in companion flanges or drive-line length. And they have the same shift lever controls as the 3-speed units.

A top-mounted power take-off capable of transmitting full engine torque is available for use with the new Spicer 4-Speed Auxiliaries.

HEAVY TRAFFIC

WINTER

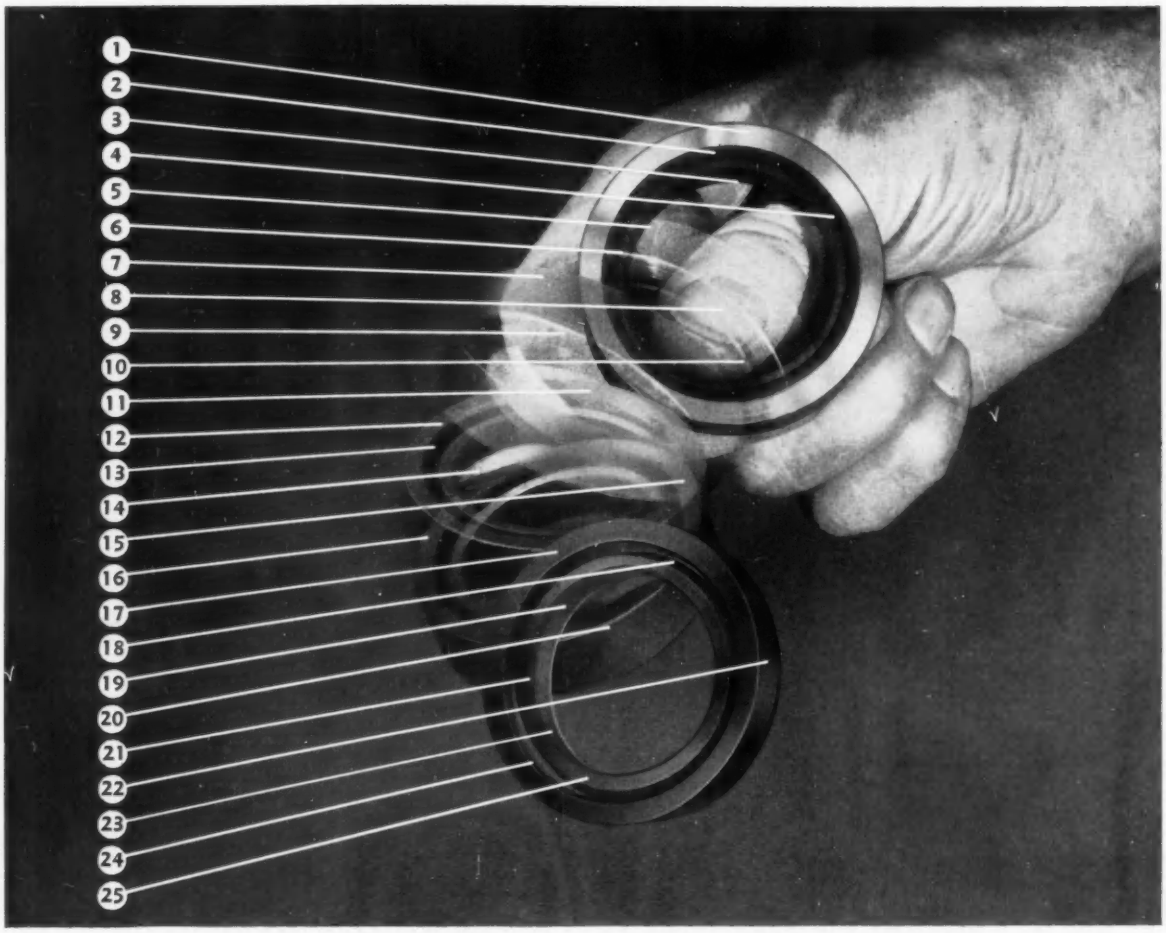


SUMMER

FLAT LAND

EMPTY

SPICER PRODUCTS: TRANSMISSIONS • UNIVERSAL JOINTS • PROPELLER SHAFTS • AXLES • TORQUE CONVERTERS • GEAR BOXES • POWER TAKE-OFFS POWER TAKE-OFF JOINTS • RAIL CAR DRIVES • RAILWAY GENERATOR DRIVES • STAMPINGS • SPICER and AUBURN CLUTCHES • PARISH FRAMES • SPICER FRAMES



There are 25 reasons why your oil seals must be custom engineered

Before you buy a "stock" oil seal, ask yourself, "Will this seal suit my requirements?". If it does, it should answer 25 different conditions.

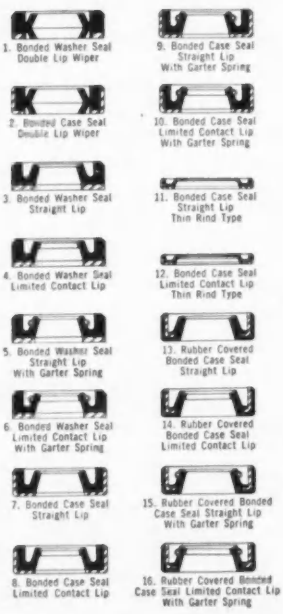
As an example, consider the seal assembly . . . Is the seal to have lip clearance? — Is the seal to be pressed in lip first or heel first? — Is the seal pressed in to a predetermined depth? — Is this a vertical or horizontal application? It is highly unlikely that a "stock" packing can meet all 25 requirements.

IPC custom-engineers every oil seal to suit your specific application. Before you buy, consult IPC. No obligation . . . IPC will show you how to simplify design, reduce cost, and insure long effective service. Technical data sheets outlining these 25 points will be mailed on request.

INTERNATIONAL PACKINGS CORPORATION

Bristol, New Hampshire

BONDED BY IPC


1. Bonded Washer Seal Double Lip Wiper
2. Bonded Case Seal Double Lip Wiper
3. Bonded Washer Seal Straight Lip
4. Bonded Washer Seal Limited Contact Lip
5. Bonded Washer Seal Straight Lip With Garter Spring
6. Bonded Washer Seal Limited Contact Lip With Garter Spring
7. Bonded Case Seal Straight Lip
8. Bonded Case Seal Limited Contact Lip
9. Bonded Case Seal Straight Lip With Garter Spring
10. Bonded Case Seal Limited Contact Lip With Garter Spring
11. Bonded Case Seal Straight Lip Thin Rind Type
12. Bonded Case Seal Limited Contact Lip Thin Rind Type
13. Rubber Covered Bonded Case Seal Straight Lip
14. Rubber Covered Bonded Case Seal Limited Contact Lip
15. Rubber Covered Bonded Case Seal Straight Lip With Garter Spring
16. Rubber Covered Bonded Case Seal Limited Contact Lip With Garter Spring

P?

Branch Offices: Chicago, Dallas, Detroit, Kansas City, New York, Philadelphia, San Francisco, St. Louis.

FIRST and FOREMOST!

AC "Standardized Dust"

e primitively mined in Arizona

precision-processed in AC laboratories in Flint!

Early in 1942, a group of AC engineers, at the request of the U.S. Army, began a search for some sort of standard test dust to check efficiency of air cleaners. Many different kinds were checked until finally a particular kind of dust found only on the Pima Indian Reservation in Arizona was selected.

Then, the engineers determined the percent of size of the grit for coarse and fine dust and set up processing procedures necessary to assure absolute uniformity. Standards were established for testing air cleaners, oil filters, gas strainers and other applications. The test dust and testing procedures were formally accepted by the Army Ordnance Department and U.S. Bureau of Standards.

Today, AC is the only American company mining, processing and marketing standard test dust. This is one more typical example of the leadership in research which keeps AC first and foremost in its field!

Watch
WIDE WIDE WORLD
and BIG TOWN
NBC-TV

AC QUALITY PRODUCTS

GM GENERAL MOTORS

AC SPARK PLUG
THE ELECTRONICS DIVISION OF GENERAL MOTORS
FLINT—1300 North Dort Highway • CHICAGO—Insurance Center Building
DETROIT—General Motors Building

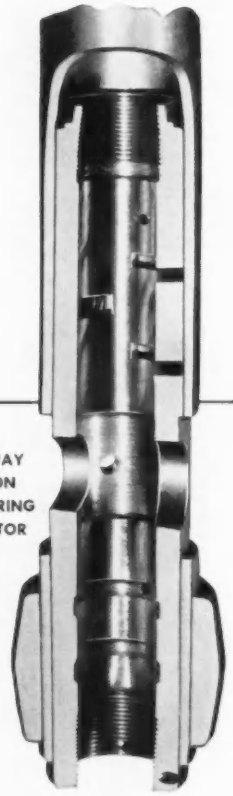
For More Than 20 Years Nearly Every Make of Car Has Used One or More AC Products

ADAPTERS (DRIVE) • AIR CLEANERS • AIR CLEANERS AND SILENCERS (COMBINATION) • AMMETERS • BREATHERS (CRANKCASE) • CAPS (RADIATOR PRESSURE) • FLEXIBLE SHAFT ASSEMBLIES • FUEL PUMPS • FUEL AND VACUUM BOOSTER PUMPS (COMBINATION) • FUEL FILTERS & STRAINERS • GASOLINE STRAINERS • GAUGES—AIR (PRESSURE) • GAUGES—GASOLINE • GAUGES—OIL (PRESSURE) • GAUGES—TEMPERATURE (WATER, OIL) • OIL FILTERS (LUBE) • PANELS (INSTRUMENT) • RECIPROCATING VACUUM PUMPS • ROTARY VACUUM PUMPS • SPARK PLUGS • SPEEDOMETERS • TACHOMETERS • TERMINALS (IGNITION WIRE) • VALVES (CRANKCASE VENTILATION)

MICROHONING*

with self-dressing abrasives generates consistent *Functional Surface Finishes*

Microhoning, the low-velocity abrading process consistently produces part after part exactly to your specified surface finish requirements, because the abrasive grits always remain sharp.



CUTAWAY SECTION OF STEERING ACTUATOR

Monroe Auto Equipment Co. designed its power steering unit to withstand rugged use while maintaining sensitive control. In the final processing of the hydraulic steering actuator, Monroe chose Microhoning to obtain diametric accuracy, consistent finish and to generate geometric precision.

The rough and finish Microhoning operations removed .005″ stock from an interrupted bore 1.125″ in diameter and 6⅜″ long.

MATERIAL AND HARDNESS: SAE 1118 steel, Rockwell 45-50C

TOLERANCES: size—.0003″
roundness and taper—.0001″

FINISH: 25 microinches or less

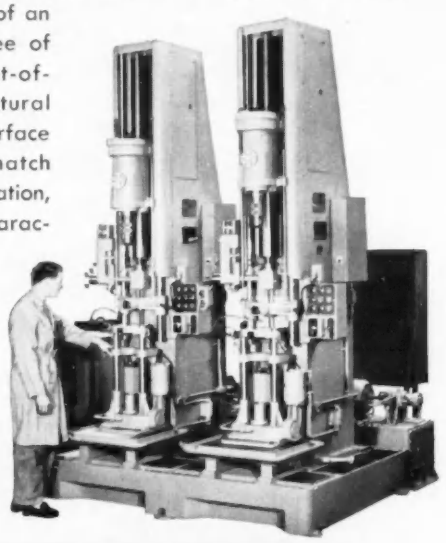
CYCLE: rough Microhoning—35 to 40 seconds
finish Microhoning—15 to 20 seconds

MACHINE: Double-column Model 740 Hydrohoner

SELF DRESSING ACTION OF THE ABRASIVES . . . is accomplished by the rotation and reciprocation of the Microhoning tool—the combined motion continuously changes the direction of force on the abrasive grits and keeps them dressed.

EFFICIENT STOCK REMOVAL . . . results from the many sharp-cutting grits acting simultaneously over a wide area of work surface. In this manner, the effect of heat is also minimized. Of all production processes, Microhoning least disturbs the sub-surface structure of the work.

FUNCTIONAL SURFACE CHARACTERISTICS . . . are obtained in one uninterrupted cycle. Microhoning generates accuracy within millionths of an inch . . . surfaces free of waviness, taper, out-of-roundness and structural stresses . . . uniform surface finish and a cross-hatch pattern for best lubrication, sealing and wear characteristics.



For more details on this application write for CROSS-HATCH Vol. 8, No. 1

***MICROHONING = STOCK REMOVAL + GEOMETRY + SIZE CONTROL + SURFACE FINISH**

MICROMATIC HONE CORPORATION

8100 SCHOOLCRAFT AVENUE • DETROIT 38, MICHIGAN

Now PARACRIL controls the "power" in power steering!

The "power" ***is oil.*** Keeping it in its place and working for you *can* be difficult. *Unless,* as one major manufacturer discovered, you put oil-resistant **PARACRIL®** on the job.

"O" rings made of this versatile chemical rubber are...

- completely impervious to hydraulic oils
- molded to close tolerances...non-swelling and non-shrinking to retain their close fit indefinitely
- *flexible* enough to seal at low pressures...*tough* enough to seal at extremely high pressures
- functional over a wide temperature range
- resistant to abrasion from metal parts in contact with them.

In brief, these Paracril "O" rings are *leakproof* and *lasting!*

And Paracril has proved its superiority in *hundreds* of similar applications. In automatic transmissions and other power units, in hydraulic hose, oil field equipment, and wherever oil, temperature, or friction raises a problem, Paracril supplies the answer.

Available in varying grades of oil resistance, in bale or crumb form, Paracril may be blended with other rubbers or resins, used wherever a rubberlike material is needed.

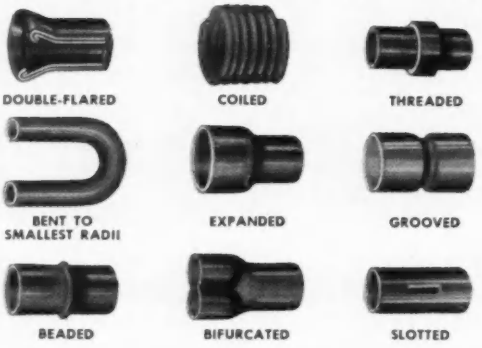
If you're not already familiar with the *many* advantages Paracril offers *you,* simply write on your letterhead to the address below.

Naugatuck Chemical

Division of United States Rubber Company
Naugatuck, Connecticut

IN CANADA: NAUGATUCK CHEMICALS DIVISION • Dominion Rubber Company, Limited, Elmira, Ontario
RUBBER CHEMICALS • SYNTHETIC RUBBER • PLASTICS • AGRICULTURAL CHEMICALS • RECLAIMED RUBBER • LATICES • Cable Address: Rubexport, N.Y.

End section of Bundyweld Tubing shows exclusive double-walled, single-strip construction (details below). Tubing is uniformly smooth, inside and out, with no bead at lap joints. Bundyweld can be fabricated easily, bends to shortest radii. Copper-coated on all exposed surfaces, facilitating coating, soldering, or brazing operations. Inset shows but a few fabrication processes.



BUNDYWELD IS DOUBLE-WALLED FROM A SINGLE STRIP

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.

Here's the reason why Bundyweld Steel Tubing is used on 95% of today's cars

Only steel tubing can take the punishment; and only Bundyweld is double-walled from a single steel strip for absolute dependability.

Look closely at the unique construction of Bundyweld Steel Tubing, and you will see the reason why it is specified by automobile manufacturers for safety and dependability.

Because of its strength, durability, and ease of fabrication, Bundyweld is universally used by the industry in brake lines, fuel lines, oil lines, and dozens of other vital automotive uses. It is found *in 95% of today's cars, in an average of 20 applications each.* Only *steel* tubing can stand up under the punishment; Bundyweld is tough, rugged, takes the wear and tear in stride.

Your product, too, may need these outstanding Bundyweld properties: leakproof by test; thinner-walled yet stronger; high thermal conductivity; easily fabricated; takes easily to standard protective coatings.

Backed by unexcelled engineering and fabrication facilities, Bundy offers a wealth of special services to its customers. Technicians are available, at your request, to help at any stage of your product development where the right answer to a tubing question is vital.

For information, write, wire, or call us today!

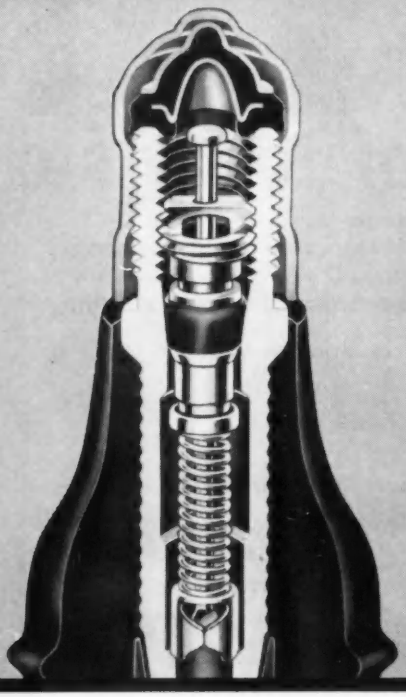
BUNDY TUBING COMPANY • DETROIT 14, MICHIGAN

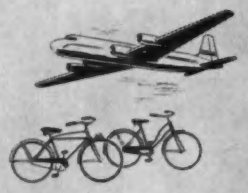
BUNDYWELD TUBING®

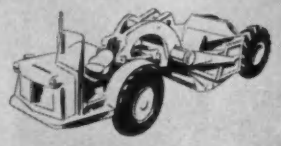
Bundy Tubing Distributors and Representatives: ***Cambridge 42, Mass.:*** Austin-Hastings Co., Inc., 226 Binney St. • ***Chattanooga 2, Tenn.:*** Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • ***Chicago 32, Ill.:*** Lapham-Hickey Co., 3333 W. 47th Place • ***Elizabeth, New Jersey:*** A. B. Murray Co., Inc., Post Office Box 476 • ***Los Angeles 58, Calif.:*** Tubesales, 5400 Alcoa Ave. • ***Philadelphia 3, Penn.:*** Rutan & Co., 1717 Sansom St. • ***San Francisco 10, Calif.:*** Pacific Metals Co., Ltd., 3100 19th St. • ***Seattle 4, Wash.:*** Eagle Metals Co., 4755 First Ave., South ***Toronto 5, Ontario, Canada:*** Alloy Metal Sales, Ltd., 181 Fleet St., E. • **Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.**

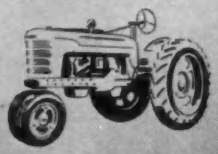
WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING • AFFILIATED PLANTS IN AUSTRALIA, ENGLAND, FRANCE, ITALY, AND GERMANY

LOOK TO SCHRADER...

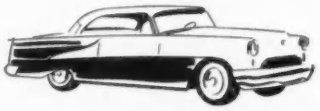


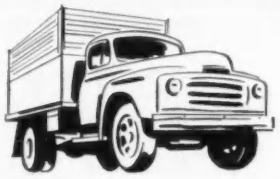






**for the finest,
latest,
safest
tire valve products
for all types of
vehicles**





A. SCHRADER'S SON
Division of Scovill Manufacturing Company, Incorporated
470 Vanderbilt Avenue, Brooklyn 38, N. Y.

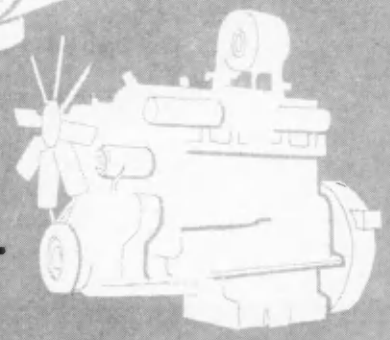
Schrader®
ESTABLISHED IN 1844

FIRST NAME IN TIRE VALVES FOR
ORIGINAL EQUIPMENT AND REPLACEMENT

"How do you know when an engine needs attention?"

...you get the Complete Answer from the built-in

VEEDER-ROOT Rev-Counter



These rugged counters record the shaft-revolutions of engines, generators, compressors, heaters and other equipment. So you *dnd your customers* can see at a glance how your equipment is holding up to its guarantee . . . whether it needs replacement parts . . . when routine maintenance is coming due.

That's why it pays, in designing engines of any type, to build-in the genuine Veeder-Root Rev-Counter as a standard integral part . . . as has been done for many years by leading builders of tractors and aircraft.

Take note, too, that this counter is available with *tachometer take-off* . . . and that it may be furnished geared to any engine rpm. So build up your sales . . . build the Veeder-Root *Rev-Counter* into *your* product. Write:

Everyone can Count on...

VEEDER-ROOT
The Name that Counts

VEEDER-ROOT INCORPORATED
HARTFORD 2, CONNECTICUT

STOCKS OF STANDARD COUNTERS AVAILABLE AT
Greenville, S. C. • Chicago 6, Ill. • New York 19, N. Y. • Los Angeles • San Francisco
Montreal 2, Canada • Offices and Agents in Other Principal Cities

For easy cleaning... genuine Leather

Genuine leather upholstery gives you a lot of sales features.
One of the best is its easy cleanability. Oil and grease,
food and beverage stains, mud and grime—they all swish right off
with a damp cloth and mild soap. No special treatment, no waxing or polishing
no dry-cleaning. Just an occasional washing to get rid of surface grime. No
wonder leather upholstery sews up the sale so often!

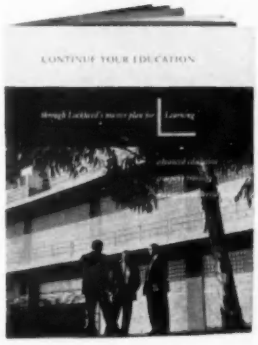
Only genuine leather wears as well as it looks

THE UPHOLSTERY LEATHER GROUP, INC. • **99 West Bethune, Detroit 2, Mich.** • 141 East 44th Street, New York 17, N.Y.

to career-conscious **ENGINEERS:**

CONTINUE YOUR EDUCATION...

. . . at little or no cost to you at U.S.C., U.C.L.A. *and* LOCKHEED



Engineers interested in advancing their education and career will find Lockheed's new brochure, "Continue Your Education" of interest. It details day and evening programs open to engineers at the University of Southern California, University of California at Los Angeles and at Lockheed. Coupon below is for your convenience in requesting the brochure.

The work of today's aircraft engineer is becoming ever more complex.

His position and career require constantly increasing theoretical and practical knowledge. His intellectual and professional curiosity demand educational growth.

This "need to know" is welcomed at Lockheed. It is a vital factor in Lockheed's engineering leadership. It is the basis of untold engineering achievements.

To help engineers in their quest for knowledge, the California Division of Lockheed has developed a comprehensive series of training and scholarship programs. They are adapted to Lockheed engineers in all fields, at all levels.

Within this Master Plan for Learning, every engineer will find a program best adapted to his requirements.

To engineers who lack aircraft experience.

Aircraft experience is not necessary to join Lockheed. It's your engineering training and experience that count. Lockheed trains you for aircraft engineering–at full pay.

California Division

LOCKHEED

Aircraft Corporation

Burbank, California

Mr. E. W. Des Lauriers, Dept. CE-16-6
Lockheed Aircraft Corporation
Burbank, California

Please send me a copy of your brochure, "Continue Your Education."

My name _____

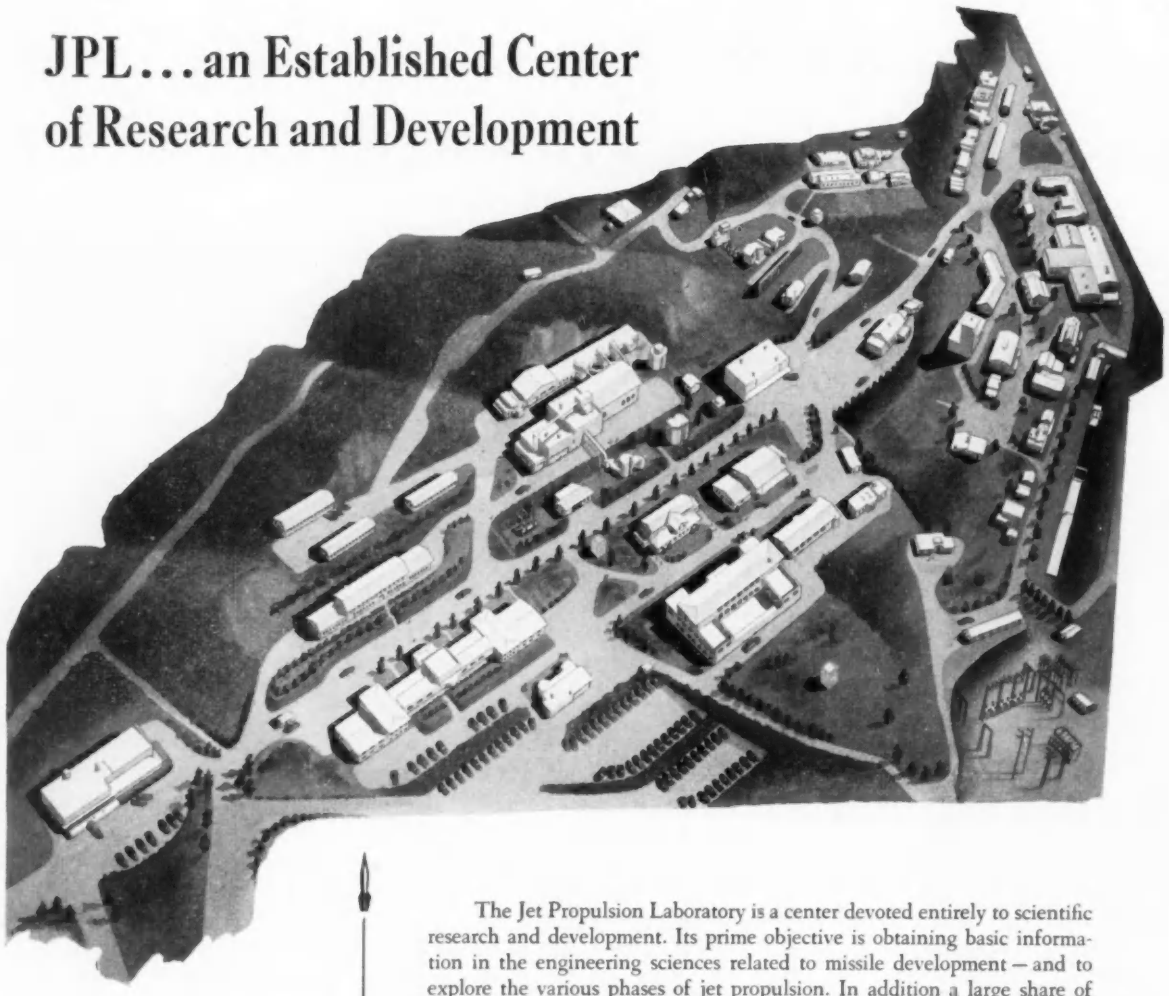
My home address _____

My field of engineering _____

My home phone _____

My city and state _____

JPL... an Established Center of Research and Development



★ At this time we are particularly interested in interviewing graduate engineers and scientists in the fields of aerodynamics, aircraft structures, mechanical engineering, chemistry, chemical engineering, heat transfer, electronics, systems analysis, electromechanical instrument design, instrumentation, metallurgy, nuclear physics and solid state physics.

These men should be definitely interested in scientific research and development relating to the problems of the future.

The Jet Propulsion Laboratory is a center devoted entirely to scientific research and development. Its prime objective is obtaining basic information in the engineering sciences related to missile development — and to explore the various phases of jet propulsion. In addition a large share of its program is devoted to fundamental research in practically all of the physical sciences.

The Laboratory extends over more than 80 acres in the foothills of the San Gabriel mountains north of Pasadena. It is staffed entirely by personnel employed by the California Institute of Technology and conducts its many projects under contracts with the U.S. Government.

Exceptional opportunity for original research coupled with ideal facilities and working conditions have naturally drawn scientists and engineers of a very high caliber. These men, working in harmony, are building a very effective task force for scientific attack on the problems of the future.

An unusual atmosphere of friendliness and cooperation is apparent at the "Lab" and newcomers soon sense the warmth of their acceptance. New advanced projects are now providing some challenging problems — and good jobs for new people.

If you would like to develop your skill and knowledge at the "Lab" and, at the same time, help us solve some of our problems — write us today.

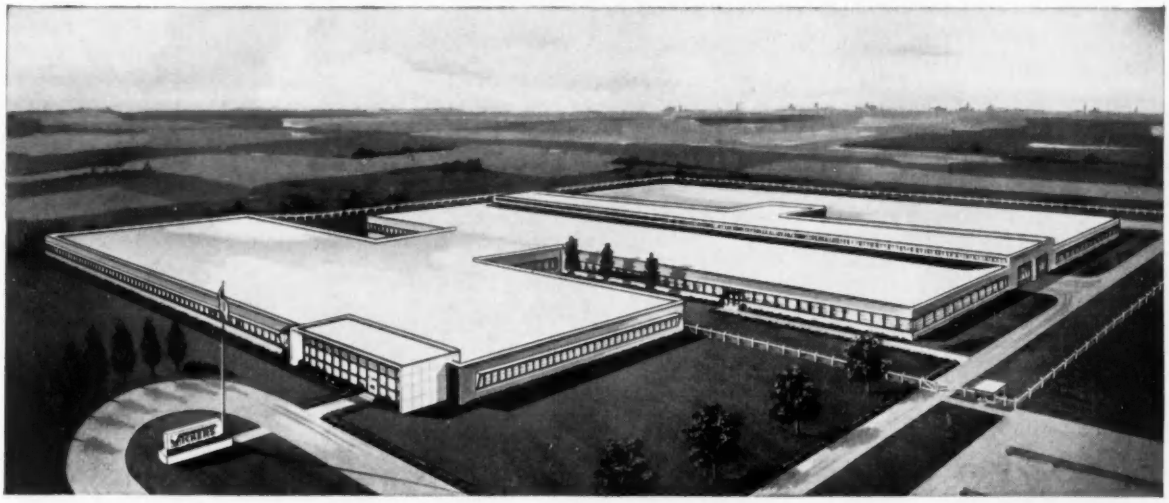
CALTECH jpl **JET PROPULSION LABORATORY**

A DIVISION OF CALIFORNIA INSTITUTE OF TECHNOLOGY

PASADENA, CALIFORNIA

VICKERS

NEW ADMINISTRATIVE and ENGINEERING CENTER



Dedicated to the **Development** and **Improvement** of **Hydraulic Components and Systems**

Vickers, a pioneer in oil hydraulics for a wide variety of uses, has maintained leadership through the years by means of aggressive and extensive research.

Continuing rapid expansion of the oil hydraulics requirements of industry has brought with it the need for augmented research and engineering facilities. To meet this need, Vickers has just completed this new building in suburban Detroit . . . 150,000 square feet devoted entirely to research, development, engineering application and administration.

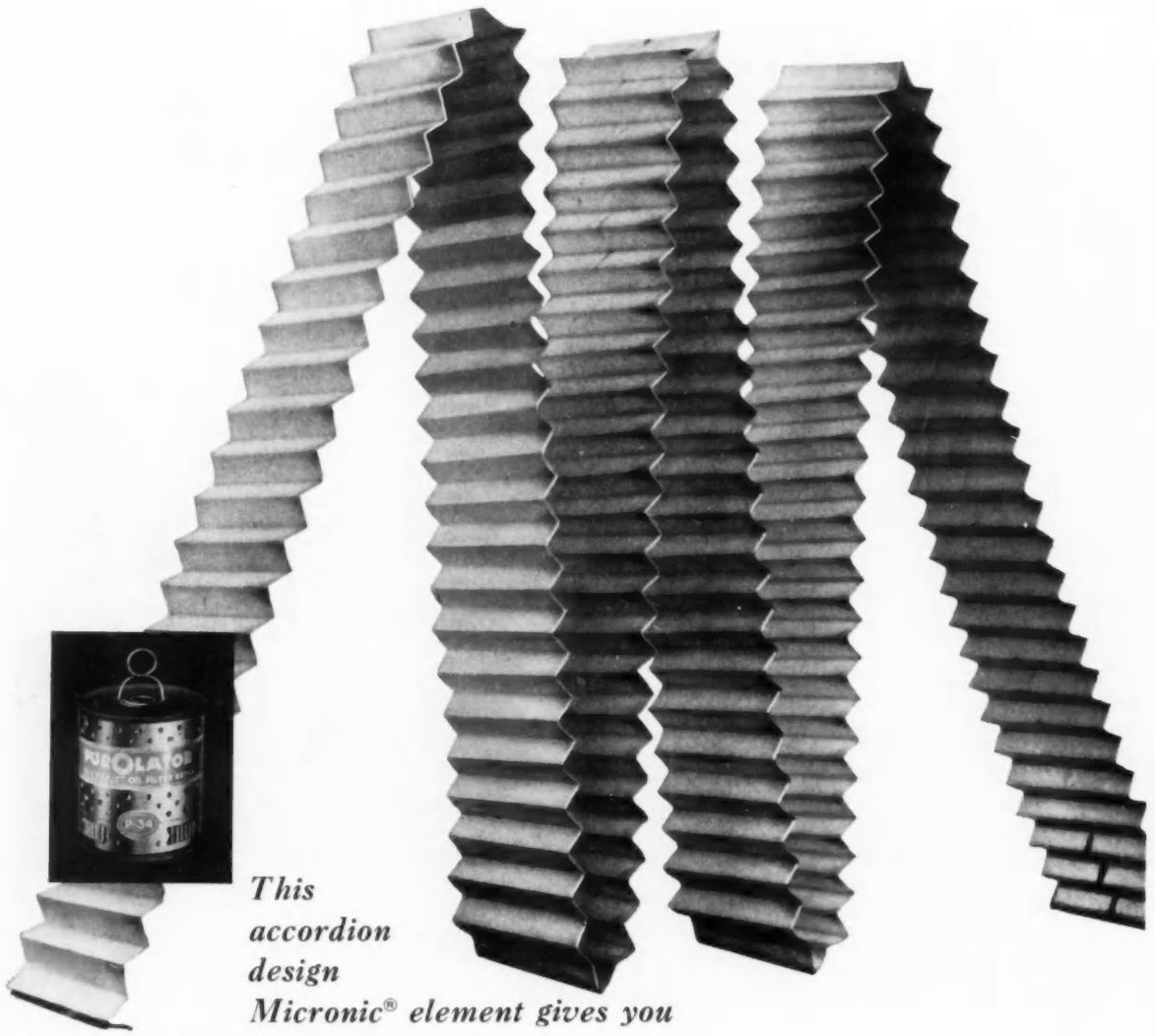
A milestone in Vickers progress, this new Administrative and Engineering Center is also a promise of future benefits to users of Vickers hydraulic components and systems.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
ADMINISTRATIVE and ENGINEERING CENTER
Department 1440 • Detroit 32, Michigan

Application Engineering Offices: • ATLANTA • CHICAGO • CINCINNATI • CLEVELAND DETROIT • HOUSTON • LOS ANGELES AREA (El Segundo) • MINNEAPOLIS • NEW YORK AREA (Summit, N.J.) • PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) • PORTLAND, ORE. • ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE • ST. LOUIS TULSA • WASHINGTON • WORCESTER
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto

7385

Engineers and Builders of Oil Hydraulic Equipment Since 1921



This accordion design Micronic® element gives you

10 times more filtration area for full engine protection

Pull out Purolator's accordion design and you'll see how Purolator packs 10 times more filtration area into its element than most filters. You'll find it provides maximum filtering area in minimum space, assuring *full* engine protection as no other filter can.

Controlled porosity of Purolator's Micronic® element filters out particles as small as .000039 of an inch, yet never removes costly additives in heavy-duty or detergent oils and never channels. The Micronic® element, made of plastic-impregnated cellulose, isn't affected by engine temperature, crankcase dilution, or water.

Engine manufacturers have proved time and time again that these wear-reducing features make an engine perform better and last longer. Find out how they can do the same job for you. Write for our new 32-page "Filtration Manual for Product Designers"—and please enclose 25¢ to cover postage and handling. Address Dept. A4-176

PUROLATOR

"FIRST IN THE FIELD OF FILTERING"

PUROLATOR PRODUCTS INC., Rahway, N. J., and Toronto, Ontario, Canada

MIDLAND'S Tractor-Trailer Braking System Meets LATEST Regulations ...*AND THEN SOME!*

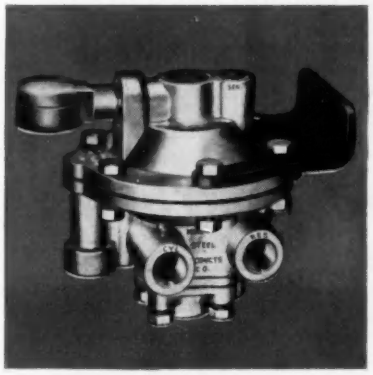
● Midland's tractor-trailer braking system meets all the latest safety regulations and gives you EXTRA, important benefits:

1. Tractor protection with the Midland system is *AUTOMATIC*, so important in split-second emergencies.
2. Midland valves are large-capacity valves, giving you faster, more positive action.
3. Midland provides a *combination* manual and automatic dash control valve for instantaneous application and release of trailer brakes.
4. Midland eliminates manual shut-off cocks.

AND, for the ultimate in braking protection, Midland offers you its new axle-by-axle system.

When you order new Tractor-trailer equipment, specify Midland Power Brakes for extra quality performance, more positive protection. Make it Midland, too, when replacing or modernizing the braking system on your present equipment. Your nearest Midland distributor is anxious to serve you. Just give him a call.

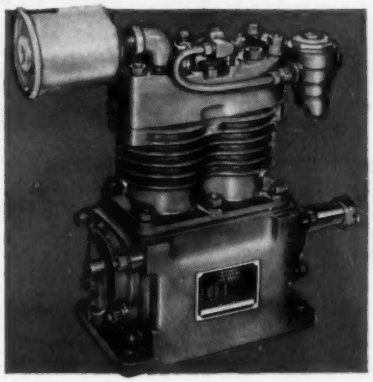
MIDLAND GIVES YOU *POSITIVE PROTECTION PLUS!*



● On Midland-equipped units, if trailer breaks away from tractor, Buzzer sounds . . . instant-acting Reservoir Check Valve automatically seals air supply, giving tractor sufficient reserve . . . Break-Away Valve permits tractor brakes to be applied to bring tractor to safe stop . . . trailer braking system automatically applies emergency feature to stop trailer!

● The new Midland Emergency Relay Valve has dual compensating controls. One operates the relay section to supply air to the brake chambers in proportion to service control line air pressure.

The other operates the emergency section which insures you against total loss of air and automatically applies trailer brakes.



● Midland Air Compressors feature patented automatic inlet valves built into the cylinder head for greater efficiency, cleaner air, cooler operation—*extra safety*. Available in models 7.4 and 12 capacities, these compressors provide ample reserve braking power for the worst traffic emergencies, require a minimum of maintenance.

THE MIDLAND STEEL PRODUCTS CO.
6660 MT. ELLIOTT AVE. • DETROIT 11, MICHIGAN
Export Department: 38 Pearl St., New York, N. Y.

Those Who Know Power Brakes
CHOOSE MIDLAND!

CPT *Has Solved Hundreds of Them*

We've built CPT Aerol Precision Ball Screws for operation at sub-zero temperatures . . . and at temperatures several hundred degrees above zero. Some CPT Ball Screws are 20 feet long, some as short as an inch or so. Some take loads measured in thousands of pounds, some in ounces.

Every CPT Aerol Precision Ball Screw is engineered for its specific job. Conditions of load, speed, input power, output power, operating temperatures, servicing convenience and weight limitations dictate its design. However, it's possible that an existing CPT Ball Screw design might be adaptable to your particular requirements with resultant savings.

Let us discuss your ball screw needs while projects are still in the early design stages.

Write for your copy of K-656. You'll see the many problems that have been solved by CPT Aerol Precision Ball Screws.

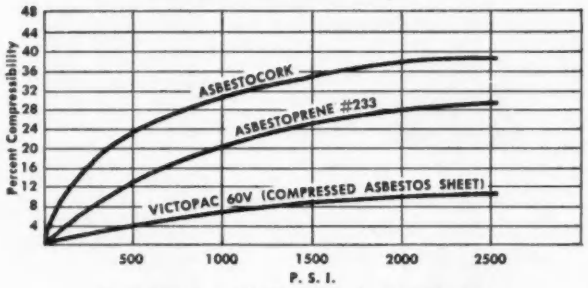
CPT

CLEVELAND PNEUMATIC TOOL CO.

3781 East 77th Street • Cleveland 5, Ohio

Sales-engineering offices in
Seattle, Los Angeles, Fort Worth-Dallas and Levittown, L. I.

Compressibility of Asbestocork compared with other Victor asbestos-synthetic rubber packings



Data based on 1/16" thick Asbestocork sheet

VICTOR

Sealing Products Exclusively

GASKETS • OIL SEALS • PACKINGS

*Trade Mark Reg. U. S. Pat. Off.

Asbestocork introduces approximately 10% greater compressibility in asbestos-synthetic rubber base sheet packing. It retains fully the heat and oil resistance, and anticorrosion values of such packing. It gets its added compressibility by the addition of cork to the composition.

For Automotive and Industrial Sealing

Asbestocork was developed especially for its wide usefulness in automotive and industrial sealing on light to medium pressures. Thorough tests on recommended applications show new levels of performance. The added advantage of economy makes it imperative that you know all about *Asbestocork*. Available in standard thicknesses, 1/32" to 1/8".

Sample Sheet and Technical Data on Request

Your inquiry invited; no obligation. Please state proposed application. Prices quoted on sheet stock or finished gaskets if desired. Victor's highly developed rule die-cutting technique assures big savings on finished gaskets in any quantity.

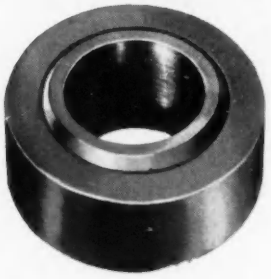
Contact your Victor Field Engineer, or address Victor Mfg. & Gasket Co., P. O. Box 1333, Chicago 90, Ill. In Canada: Victor Mfg. & Gasket Co. of Canada Ltd., Victor Drive & Chester St., St. Thomas, Ont.

'MONOBALL'' SELF-ALIGNING BEARINGS

BORE SIZES UP TO 6″ DIAMETER

ROD END TYPE

PLAIN TYPE



Tens of thousands in aircraft use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16″ to 6″ Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Field Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. New types have been developed, many as a result of specific requirements of our customers. Write or wire now for revised Engineering Manual.

Analysis

1. Chrome Moly Steel Ball & Race
2. Stainless Steel Ball & Race
3. Bronze Race and Chrome Moly Steel Ball

Recommended Use

1. For types operating under high radial ultimate loads (3000–893,000 lbs.)
2. For types operating under high temp. (800–1200 degrees F.)
3. For types operating under normal loads with minimum friction requirements.

★ SOUTHWEST PUSH-PULL CONTROLS ★

MECHANICAL COMPRESSION AND TENSION TYPE

POSITIVE remote manual control for actuating mechanical, hydraulic or electric devices. Southwest Controls remain in selected position and are not materially affected by changes in routing due to structure movement. Save on weight, simplify installations. Standard "O" rings seal both ends. Spherical shells in tube take the compression load and cable takes tension load.

Three Types

1. Light Duty—Compression Ult. Load 1250 lbs.; Ult. tension 960 lbs.
2. Heavy Duty—Compression Ult. Load 1650 lbs.; Ult. tension 960 lbs.
3. Extra Heavy Duty—Compr. Ult. Load 3050 lbs.; Ult. tension 3900 lbs.

Modernize your push-pull control system with Southwest Mechanical Push-pull Controls. Eliminate bell cranks, pulleys and dual cables. Send for ENGINEERING MANUAL giving detailed prints and complete specification covering materials, finishes, capacities. Please address Dept. SAE-56.

★ ★ ★

Southwest Push-Pull Controls are used on Convair 240 and 340; Douglas DC-6, DC-6B, and DC-7; Lockheed Constellation 949 and 1049; and other leading aircraft.

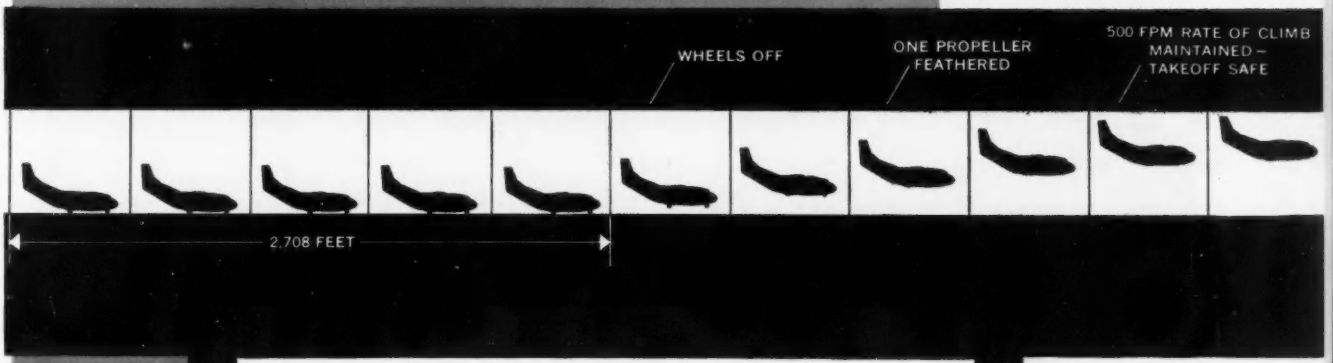
★

SOUTHWEST PRODUCTS CO.

Duarte, California

C-123 TURBOJET COMBINATION PROVES OUTSTANDING

MISSION: Combat Test Problem
WEIGHT: 13,000 lbs. Overload
TAKEOFF CONDITION: Power Failure
RESULTS: Successful



In a recent test for the U. S. Air Force, the Fairchild C-123 proved the value of thrust assist in meeting emergency single engine conditions!

A C-123 was equipped with two Fairchild J-44 jet engines and loaded to achieve gross weight of 66,742 pounds – *13,000 pounds overload.*

During takeoff and climb, both jets were operated to provide 2,000 pounds continuous thrust in addition to the two piston engines. At 2,708 feet, wheels were off the ground, and a moment later at a speed of 122 knots, one propeller was feathered!

From this takeoff position, the C-123 climbed out at 500 feet per minute – proving again its *big job capability and assault versatility,* heightened by jet augmentation to give extra power and extra safety in any emergency.

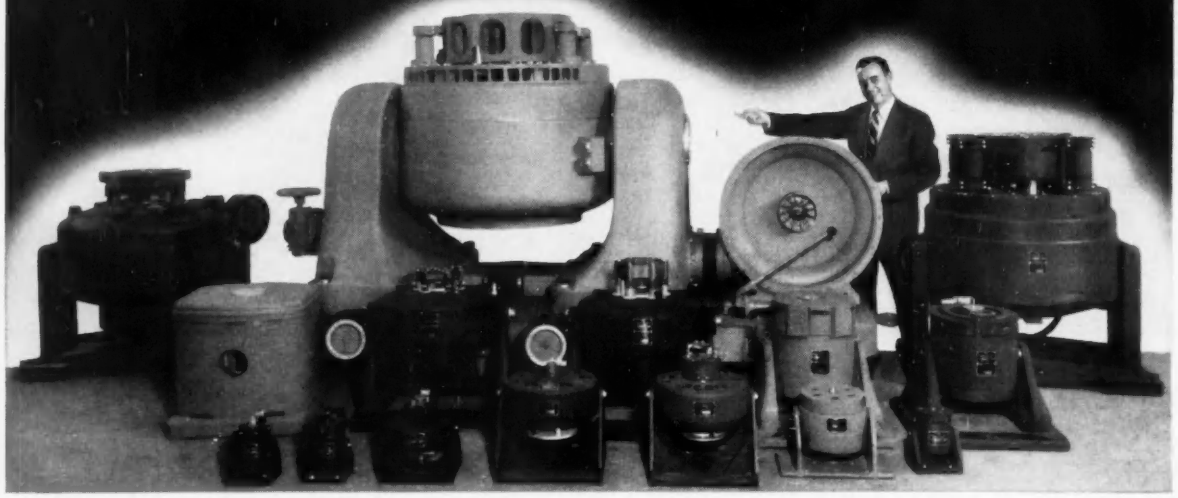
A Division of Fairchild Engine and Airplane Corporation

WHERE THE FUTURE IS MEASURED IN LIGHT-YEARS!

FAIRCHILD

AIRCRAFT DIVISION • HAGERSTOWN, MARYLAND

Look at this progress in vibration exciters



A whole range of MB Shakers developed to handle any vibration testing program . . . deliver reliable, quantitative data

One pound to over twelve thousand pounds . . . that's the range of force outputs in this group of MB electrodynamic vibration exciters. On the way are shakers for 25,000, 50,000 and even 100,000 pounds! All operate over substantial frequency range. What a far cry from the limited scope of mechanical shakers . . . the only type available just a short ten years ago.

But force and frequency range are not the only improvements. MB has long recognized the need for *pure* table motion if test results were to be quantitative and reliable.

Thus, in MB Shakers, moving-element structures are very rigid. This minimizes table motion distortion in the testing range. Also, because MB power supplies are designed for negligible harmonic distortion, table waveform is pure over the whole frequency range.

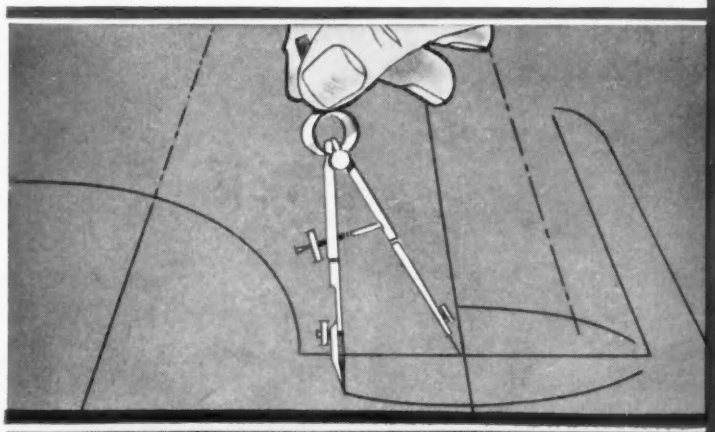
There's more. MB has designed complex wave testing systems that shorten test time and give truer reproduction of actual service conditions. Also oil-filled exciters capable of operation at "100,000 ft. altitude," —100 to +200°F, and 20 to 95% relative humidities. Also cycling systems that do time-consuming test procedures *automatically.*

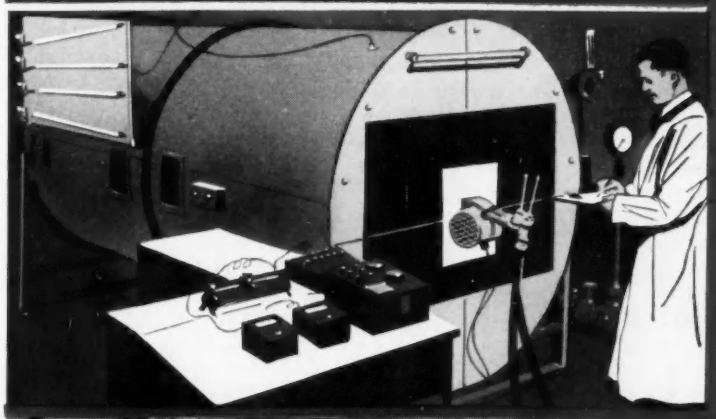
If you're working on projects that call for environmental testing, or fatigue testing, or noise determinations . . . you can benefit from vibration testing with MB shakers. Work with a leading source of help and information in this growing field . . . contact MB. For details and specifications on MB Exciters, send for Bulletin 420-7.

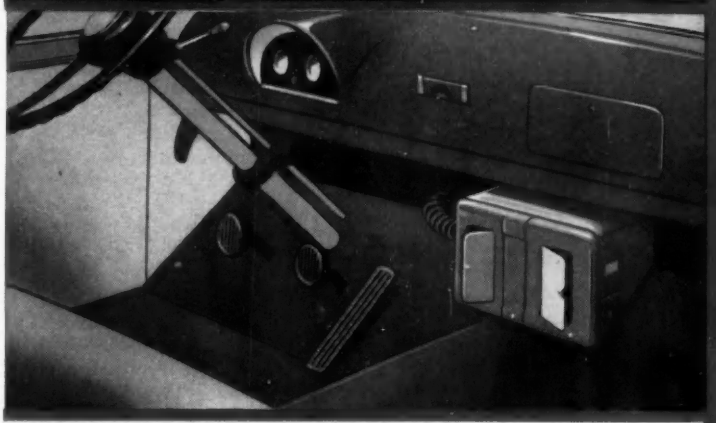
MB *manufacturing company*
A division of Textron American, Inc.
1060 State Street
New Haven 11, Conn.

HEADQUARTERS FOR PRODUCTS TO ISOLATE VIBRATION . . . TO EXCITE IT . . . TO MEASURE IT.

Protect your truck's good name with a heater designed for trucks







Do the heaters you install in your trucks measure up to the high quality you build into those trucks? If they're Evans heaters you can be sure they match your trucks in quality, performance and long life. ***Here's why . . .***

Custom-designed by heater engineers

Evans original-equipment heaters are designed into your trucks as integral parts—to save you installation time and cost, to blend into design and space allowances of your trucks, and to provide full-balanced comfort, ventilation and defrosting for any kind of weather. Evans truck heating engineers work closely with your engineers. And the cost is less than you'd think for a genuine, custom-designed truck heater!

Rigidly tested in Evans' modern laboratory

Evans has one of the most extensive, most complete testing laboratories of any independent truck heater manufacturer. Each custom-designed heater and its components must pass all of Evans' rigid specifications with flying colors before being released for manufacture. And Evans backs its testing policy to the hilt with a parts "repair or replace" warranty on every heater, good for one year or 50,000 miles, whichever occurs first!

Tailor-built for your specific truck models

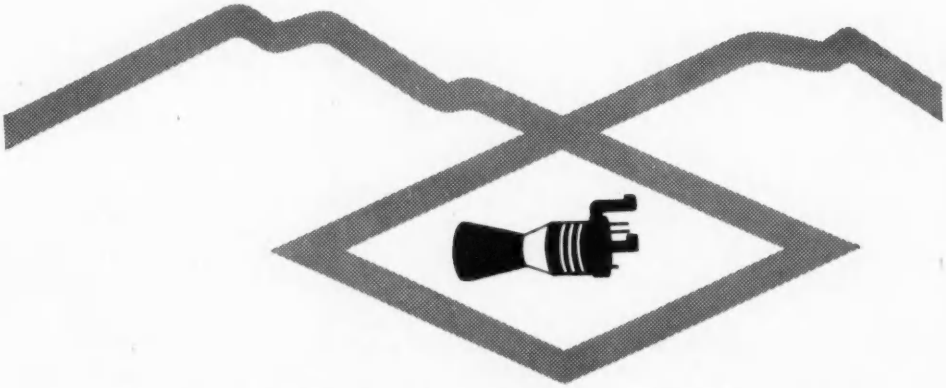
Evans engineers make sure that the heater custom-built for each of your specific truck models is not a "tacked-on" or "bolt-it-here-maybe" type, but an actual integrated unit built compactly and neatly into the truck. That's why Evans heaters, complete with *your own nameplate*, look like the quality products of your own factory!

Free Consulting Service and Heater Catalog! At no cost to you, one of our engineers will call to discuss your heater problems for any truck model, present or future. And write now for your free Evans heater catalog! Address: Evans Products Company, Dept. Z-6, Plymouth, Mich.

REGIONAL REPRESENTATIVES: Cleveland, Frank A. Chase • Chicago, R. A. Lennox Co., Inc. Detroit, Chas. F. Murray Sales Co. • Allentown, Pa., P. R. Weidner.

EVANS PRODUCTS COMPANY
also produces: railroad loading equipment; bicycles and velocipedes; Evaneer fir plywood; and Evanite battery separators.

GOOD NEWS FOR TURBINE SPECIALISTS



If you are a turbine specialist, turbomachinery engineer—or interested in any phase of the design, development testing or manufacture of large, liquid-propellant rocket engines—we can offer you some outstanding job opportunities.

We are one of the country's leading manufacturers of rocket engines for the Armed Services and the missile industry, with a 10 year backlog of experience in all phases of rocket engine development and manufacture.

New engine designs, new pumps and the powerful turbines to drive them, and the testing of completed engines to meet the rugged requirements of space flight are just some of the interesting phases of our work.

What's more, we offer you the added attraction of working and living in the beautiful San Fernando Valley in Southern California. It's to your advantage to write immediately.

Thermodynamicists—To analyze and develop high speed, subsonic and supersonic turbines. Aircraft jet engine or industrial steam turbine experience desired.

Turbomachinery Engineers—To work on the analysis, design and development of high speed rotating machinery. Openings are available for specialists in Gearing, Bearings, Rotating Seals, Subsonic and Supersonic Turbines, Centrifugal and Axial Flow Pumps and related mechanical activities.

Analytical and Experimental Development Engineers—With background in Thermodynamics, Aerodynamics, or Hydrodynamics, to work on subsonic and supersonic turbines, radial and axial flow pumps and other problems associated with high speed rotating machinery.

Engineers—Mechanical and Aerodynamic Engineers with experience on compressors, turbines, high speed axial flow and centrifugal pumps for analysis, design and experimental development work on high speed turbomachinery.

General Mechanical Design of components of high speed rotating machinery such as gears, bearings, rotating seals, hydraulic drives and transmissions, turbines and pumps.

Hydrodynamicists for analytical and experimental development work on centrifugal and axial flow pumps.

Aerodynamicists and Thermodynamicists for analytical and experimental development work on high speed subsonic and supersonic turbines.

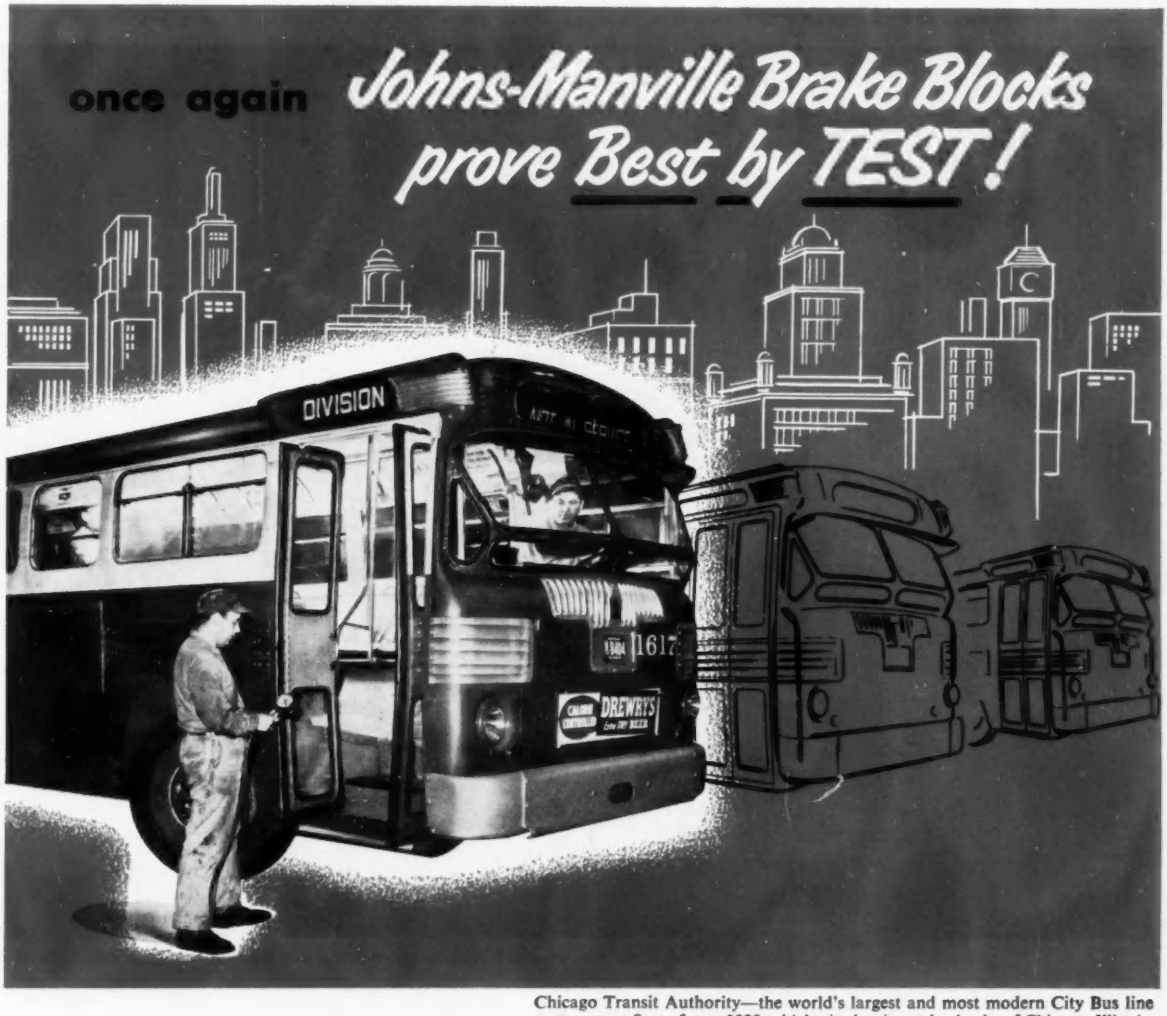
Stress Analysts with experience on high speed turbomachinery. Background in gas turbine and jet engines preferred.

Write Mr. Grant Baldwin, Rocketdyne Engineering Personnel, Dept. 596 SAE, 6633 Canoga Ave., Canoga Park, Calif.

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.

BUILDERS OF POWER FOR OUTER SPACE



Chicago Transit Authority—the world's largest and most modern City Bus line —operates a fleet of over 3000 vehicles in the city and suburbs of Chicago, Illinois.

CTA Chicago Transit Authority Buses

set new standards of performance

In recent exhaustive comparison tests conducted by the Chicago Transit Authority —where brake maintenance is a ritual— Johns-Manville Brake Blocks gave 40% and 80% more mileage than that given by Brand B and Brand C. On new bus equipment operating under regular service conditions —these quality Johns-Manville Brake Blocks clearly demonstrated lower brake cost per mile, smoother stops, minimum shop and out-of-service time.

Johns-Manville 4-Star Brake Blocks can bring you these benefits, too. To match your requirements they are available in individual units, or combination sets of high, medium or low frictional characteristics. Regardless of the type of brake, or service conditions under which it must operate, there is a J-M Brake Block custom-engineered for the specific job it has to do.

Johns-Manville Field Engineers will help study your fleet operation and assist you in selecting the precise brake blocks which best match your particular operating conditions. There is no charge or obligation involved.

Write today for helpful information on any brake problem. Address: Johns-Manville, Box 60, New York 16, New York.

JM Johns-Manville PRODUCTS **Johns-Manville** *asbestos* **BRAKE LININGS**

Gardner-Denver... Serving the World's Basic Industries

Keller Tool 4-Spindle Air-Powered Nut Setter attaches power take-off to rear axle assembly.

Line it up and GO . . . with a Keller Tool Multiple Nut Setter

No other nut setter gives you all these important features in one tool:

1. REGULATED AIR PRESSURE TO EACH SPINDLE for individual control to close torque tolerances. Eliminates additional torque inspection.

2. ALL COMPONENTS SPECIFICALLY DESIGNED for multiple nut running.

3. EXTREME FLEXIBILITY permits motor units of any size in the same tool. Tight bolt clusters at different elevations and angles. Handles placed conveniently.

4. QUICK CONVERSION to other tool applications. Standard components make this a simple job. Only the mounting plate and tubing change.

Maybe you have a multiple nut running job? Send us a blueprint. Keller Air Tool designers will suggest money-saving assembly tools and methods.

GARDNER - DENVER

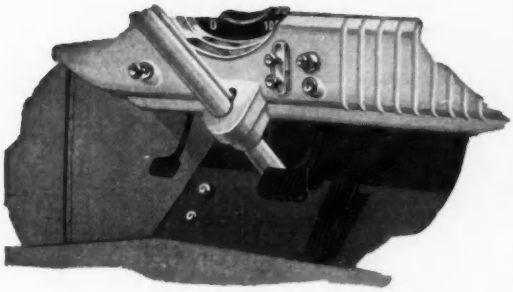
KELLER TOOL division, Grand Haven, Michigan

THE QUALITY LEADER IN COMPRESSORS, PUMPS, ROCK DRILLS AND AIR TOOLS FOR CONSTRUCTION, MINING, PETROLEUM AND GENERAL INDUSTRY

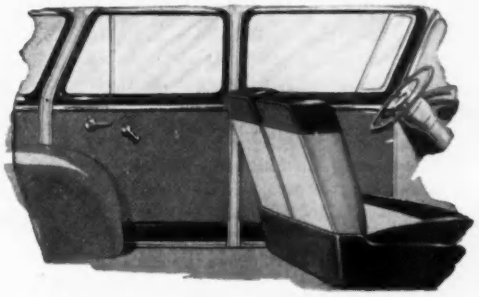
WHY NOT Naugatuck Marvibond

Catch-Alls

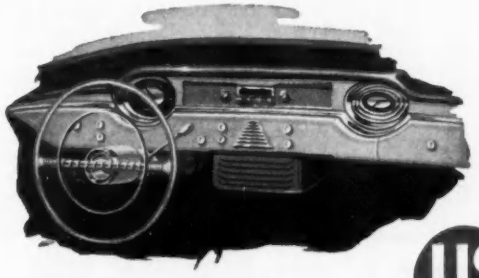
the new vinyl-to-metal laminating process?



Kick-Shield Panels



Interior Panels And Fenders



Radio/Heater Cabinets

Are you using sheet metals that have to be finished for appearance sake... that do not add any additional sales value because the finish can chip, crack, or peel? Then why not consider the advantages of Marvibonded metals?

Marvibond* is Naugatuck's new laminating process that permanently bonds Marvinol® vinyls to practically any metal. Bonded in flat sheet form, these laminates can then be bent, crimped, drilled, punched, or deep-drawn without fracturing the finish—without weakening the adhesive. And they're available in practically any surface effect... glossy or matte finishes, leather-like grains, marble patterns, prints, weaves—even sculptured appearances.

Marvibond vinyl-to-metal laminates give surfaces that...

- **can't rust, rot, or corrode**
- **can't chip, crack, or craze**
- **are scuff- and stain-resistant**
- **are warm and friendly to the touch**
- **are clean, comfortable, and easy to maintain**

Marvibond laminates can be used almost everywhere that sheet metal is used... dashboards, window trim, door panels, truck cabs and other interior automotive components. Why not consider what Marvibonded metals offer in beauty, protection and serviceability, in *extra* sales appeal and production economies?

For technical data, samples, and the names of licensed Marvibond laminators in your area, write to the address below today.

*Patent applied for

United States Rubber

Naugatuck Chemical Division

Naugatuck, Connecticut

BRANCHES: Akron • Boston • Gastonia, N. C. • Chicago • Los Angeles • Memphis • New York • Phila.
IN CANADA: Naugatuck Chemicals, Elmira, Ontario • Rubber Chemicals • Synthetic Rubber • Plastics • Agricultural Chemicals • Reclaimed Rubber • Latices • Cable Address: Rubexport, N. Y.

"We wanted the best air brake equipment available...

Our decision was *Wagner Air Brakes*

says: C. H. Rose, Fleet Maintenance Superintendent
East Texas Motor Freight Lines, Dallas, Texas

EAST TEXAS MOTOR FREIGHT LINES
GENERAL OFFICES · DALLAS, TEXAS

Wagner Electric Corporation
6400 Plymouth Avenue
St. Louis 14, Missouri

Attention: General Sales Manager

Dear Sir:

Approximately three years ago our company realized the ever-increasing need of having equally as good, if not better, brakes on the small two-ton city tractor power equipment as we normally have on the regular line haul, over-the-road equipment. This meant that it would be necessary for these units to be equipped with air over hydraulic equipment. Knowing that the cost of equipping 120 small tractors, which are used in the city for moving heavily loaded trailers through traffic, was going to entail a large expenditure, we quite naturally wanted to select the best air brake equipment available. Our decision then, and still is, Wagner brake equipment.

The longevity and dependability of Wagner brake air kits are attested to by the fact that during the year of 1954 we traded in 51 of the older city tractors on new units and due to the excellent condition of the air kits on the old tractors, we had the dealers transfer them to the new tractors.

During the past few months we have added additional new tractors to our city fleets and we requested that the delivering dealers equip these units with Wagner. Some of the tractors were equipped in our own shops and, of course, wanting this particular group of trucks to be standard and have the best brakes possible, they too had new Wagner air kits installed on them.

Approximately 40% of our over-the-road line haul tractors are equipped with Wagner compressors, etc., and we find they, like our city tractors, are operating very satisfactorily, safe and economically.

Yours very truly
EAST TEXAS MOTOR FREIGHT

C. H. Rose
Fleet Maintenance Superintendent

The experience of East Texas Motor Freight Lines with Wagner Air Brakes is not unique. It is similar in many ways to the experiences of hundreds of fleet operators all over the country. It is concrete evidence that when you equip the units you manufacture with Wagner Air Brakes, you'll be providing the very best braking system available.

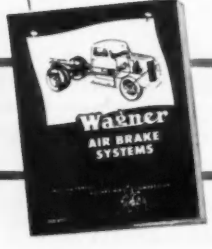
Wagner Rotary Air Compressors—9 or 12 CFM—feature rotary motion, uniform torque load, oil separation and air cooling before discharge, and easy infrequent maintenance. Fast air recovery assures an adequate supply of air pressure at all times—an important safety factor.

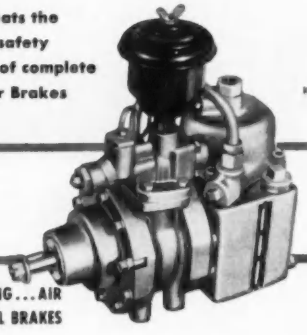
Wagner Relay and Emergency Valves assure maximum emergency protection and eliminate the need for moving large volumes of air through long air lines. Wagner Brake Application Valves provide smooth, easy stopping.

Learn the complete story on Wagner "straight-air" or "air-over-hydraulic" systems; send for your free copy of Wagner Bulletin KU-201 for full details and data.

Nothing beats the controlled safety protection of complete Wagner Air Brakes

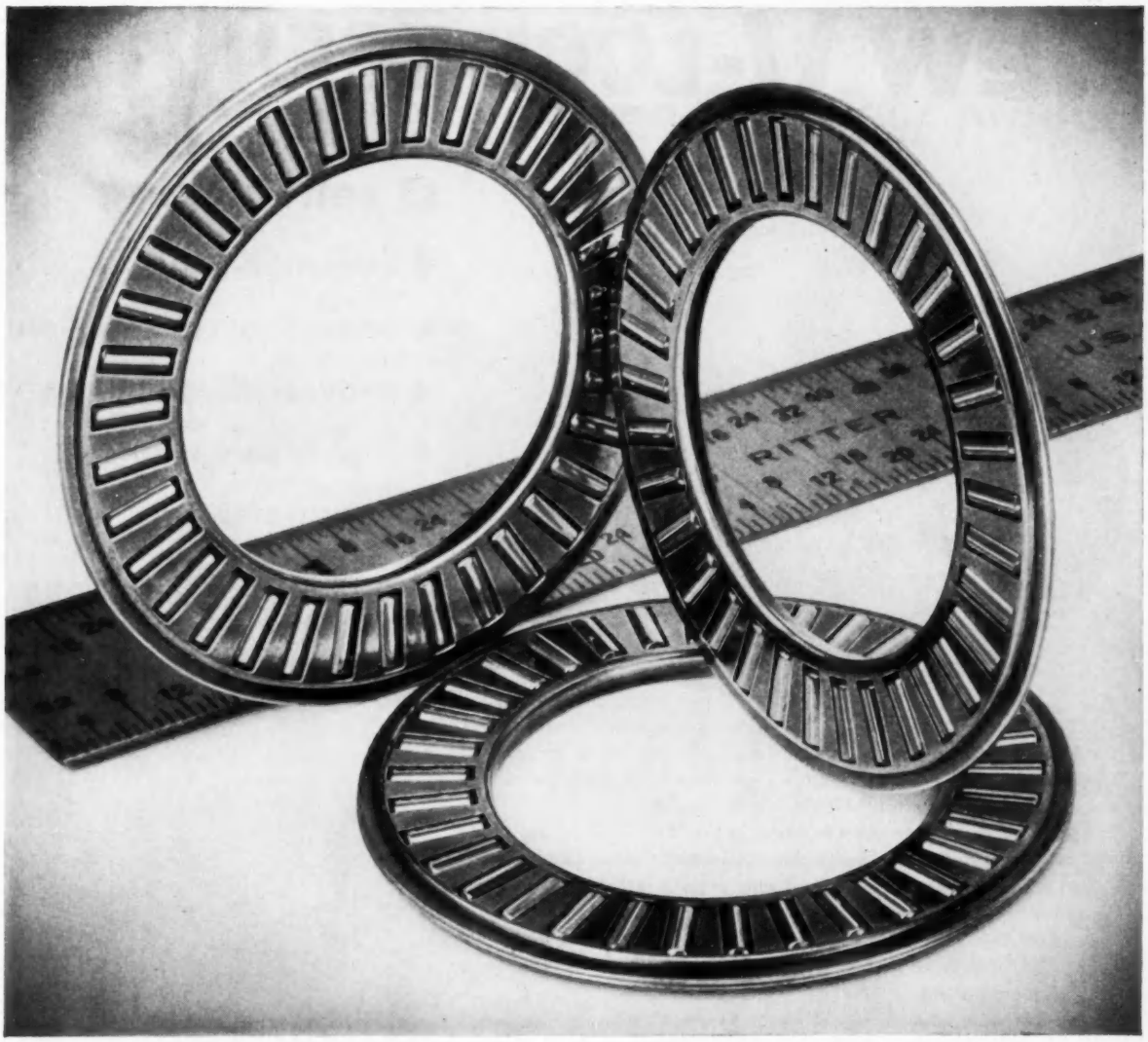
K56-38





Wagner Electric Corporation
6378 PLYMOUTH AVENUE • ST. LOUIS 14, MO., U. S. A.
(Branches in Principal Cities in U. S. and in Canada)

LOCKHEED HYDRAULIC BRAKE PARTS and FLUID...NoRol...CoMoX BRAKE LINING...AIR BRAKES...TACHOGRAPHS...ELECTRIC MOTORS...TRANSFORMERS...INDUSTRIAL BRAKES



Here's the **NEW** Torrington Needle **THRUST** Bearing!

Now designers have available a *needle bearing* exclusively for heavy *thrust* loads.

This compact Torrington Needle Thrust Bearing—only .0781" in cross section—is no thicker than an ordinary thrust washer. Yet it brings all the advantages of anti-friction operation at low unit cost for many thrust applications.

Two mating retainer halves, highly accurate steel stampings, are securely joined to form a self-contained unit closed on OD and ID. The bearing can run directly on adjacent parts, hardened to act as races, or on economical hardened and ground flat races. The bearing is piloted on the retainer bore.

In any thrust application where low unit cost, high thrust capacity and compact design are primary factors, consider the Torrington Needle Thrust Bearing. Services of our Engineering Department are available to assist you with design and application.

Send for our new Bulletin, "No. 16—Torrington Needle Thrust Bearings," for full information.

Highly successful applications of the Torrington Needle Thrust Bearing have been made in automatic transmissions, governors, steering gears, bevel gears, hydraulic pumps, and torque converters.

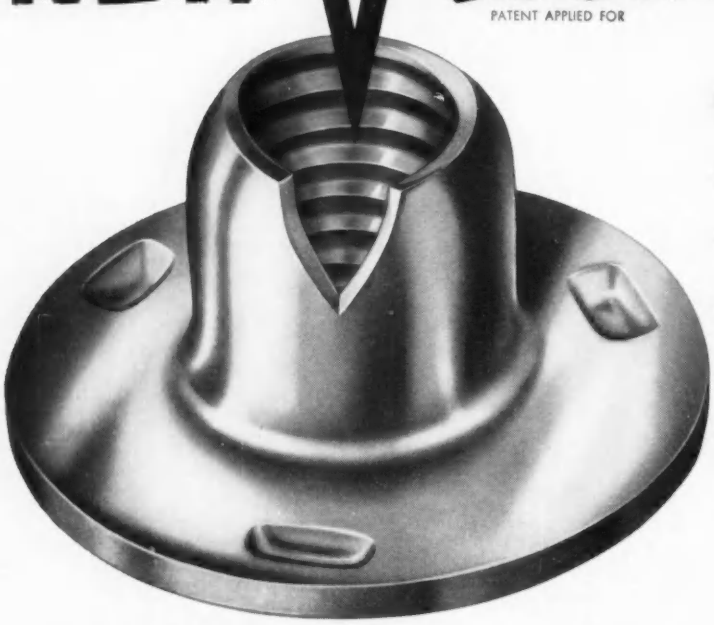
THE TORRINGTON COMPANY
Torrington, Conn. • South Bend 21, Ind.
District offices and distributors in principal cities of United States and Canada

TORRINGTON BEARINGS

Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers

NEW V-LOCK TEENUTS®

PATENT APPLIED FOR

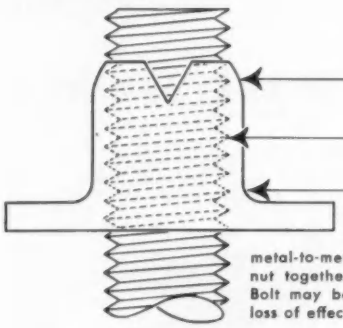


- **self-locking**
- **vibration-proof**
- **one-piece construction**
- **proven effectiveness**
- **highly adaptable**
- **re-usable**

The upper portion of this precision-made Teenut incorporates a V-type notch with the circumference of the barrel compressed inwardly toward the axis to form a permanent set. This makes it a re-usable, prevailing-torque-type, self-locking nut.

It is a one-piece, self-contained unit in which the self-locking device is an integral part of the design. No non-metallic materials or stamped parts are used so that the V-lock Teenut is not affected by heat or oils and has high tensile strength.

As the V-lock Teenut does not rely on base load to obtain its friction grip, it may also be used as a stop nut. (Indentations in base flange are welding bosses).



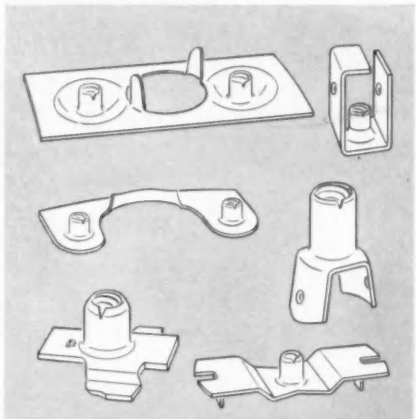
Bolt spins freely into nut until it reaches gripping area. Then, spring action creates strong, metal-to-metal wedging force, locking threads of bolt and nut together to make assembly virtually vibration-proof. Bolt may be removed and replaced many times without loss of effectiveness in nut.

The V-lock Teenut is but one of thousands of special purpose fasteners designed and manufactured by United-Carr to help speed assembly, cut costs and improve product performance. For further information on the V-lock Teenut or for help with any other fastening problem, consult your nearest United-Carr field representative or write us for his name and address.

UNITED-CARR FASTENER CORPORATION

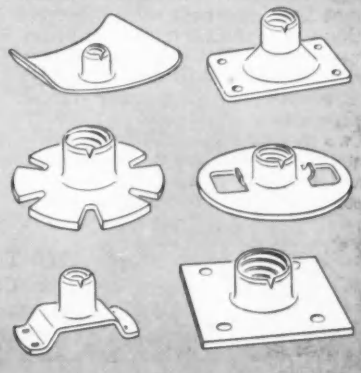
31 Ames Street Cambridge 42, Mass.

MAKERS OF DOT FASTENERS

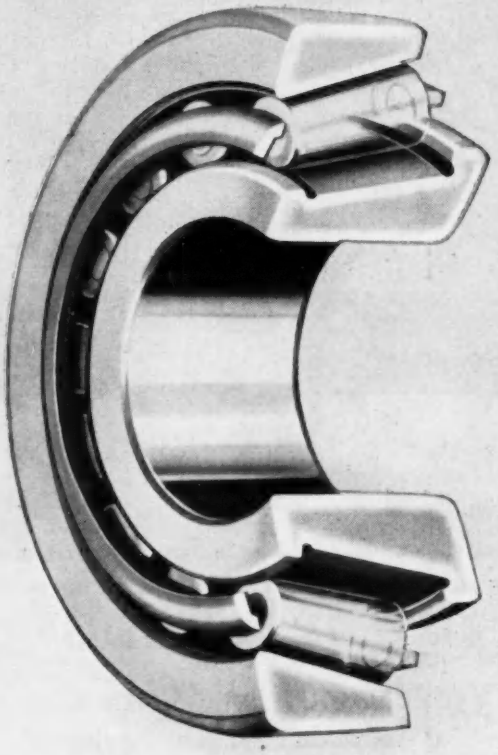


UNLIMITED VARIETY

V-lock Teenuts can be engineered in various shapes and sizes to suit customer's specifications. Can be manufactured *in volume*... in brass, bronze, stainless steel, aluminum, etc.... with unified screw threads, class 2B, in both coarse and fine thread series. Finishes: zinc, cadmium, chrome, parkerized, etc. to customer's specifications.



There's a BOWER TAPERED ROLLER BEARING engineered to fit your product



Types and sizes to fit a wide range of tapered bearing applications

There's no need to compromise with bearings! Whatever your product, if it uses tapered roller bearings, call in a Bower engineer for expert help on selecting the exact type and size you need.

Depending on your own particular needs, he'll make sure you get the exact size and type—selected from Bower's complete tapered line—engineered to assure maximum performance in your application.

Most important of all, when you specify Bower tapered roller bearings for your product, you get all the advantages of advanced Spher-O-Honed design—less maintenance, longer life, smoother operation. Get the full facts on the *complete* Bower line.

Tapered, Straight and Journal Roller Bearings for every field of transportation and industry

BOWER ROLLER BEARINGS

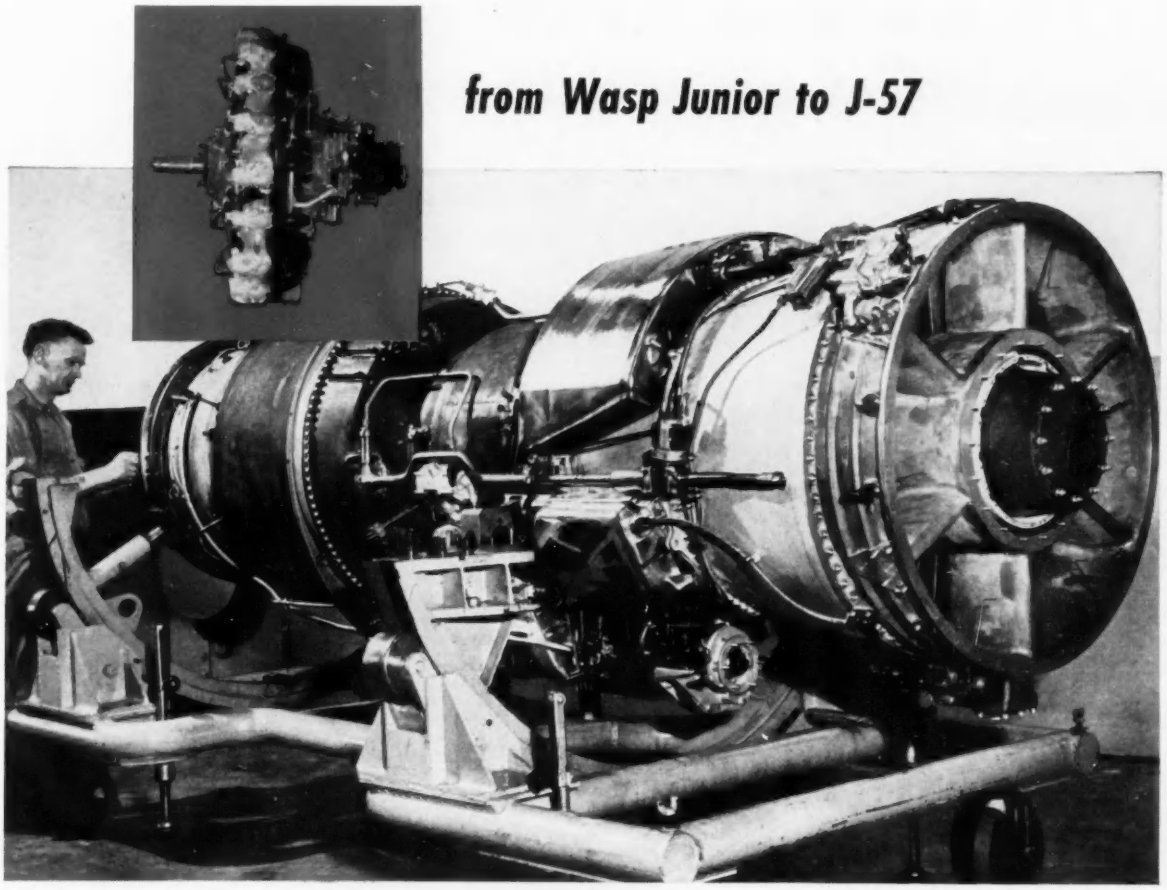
BOWER ROLLER BEARING DIVISION • *FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICH.*

Pictured above is just one example of Rohr-built Pow-R-Pax that have made Rohr famous around the world. In addition to the Convair 440 — Rohr builds the Pow-R-Pax for many other famous military and commercial airplanes including the Boeing KC-135, Douglas DC-7, and the Lockheed Super Constellation.

BUT WHAT ELSE IS ROHR FAMOUS FOR? Currently, Rohr is producing over 30,000 other different parts for aircraft of all kinds — utilizing tremendous design, engineering and production know-how gained from building thousands upon thousands of Pow-R-Pax — far more than anyone else in the world.

WORLD'S LARGEST PRODUCER OF READY-TO-INSTALL POW-R-PAX FOR AIRPLANES

ROHR
AIRCRAFT CORPORATION
Chula Vista and Riverside, California

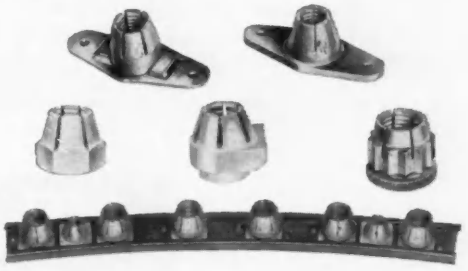


More than 25 years of engine development and the fasteners are still by ESNA

These two engines . . . built by Pratt & Whitney Aircraft over twenty-five years apart . . . dramatically reflect the evolution of aircraft power plants. Back in the early '30's engines rated at several hundred horsepower pulled air frames at speeds under 200 mph. Today the mighty J-57 develops over 10,000 pounds of thrust and rockets America's fighters through the skies at speeds faster than sound. Both of these power plants embody the finest design and high precision production skills of their era; and both engines use Elastic Stop® nuts for important fastenings.

During the past two and one half decades of power plant evolution, the greatest challenge presented to fastener manufacturers by the development of jet engines has been the increase in temperatures at which the fasteners must perform efficiently. ESNA offered the industry the first stainless steel, silver-plated, long-beam self-locking nut for performance at 1000°F. in 1947. And today ESNA is the first to produce a variety of locknut shapes manufactured from Type A286 stainless steel. These self-locking nuts will meet the full capabilities of currently produced A286 bolts at any temperature.

If you accept the practical value of more than two decades of this kind of field testing and of new development engineering to meet the needs of the industry . . . you'll rely on Elastic Stop nuts, too.



ESNA®
TRADE MARK

ELASTIC STOP NUT CORPORATION OF AMERICA

Dept. N3-675, 2330 Vauxhall Road, Union, N. J.

WE ROLL METAL

for scales that can detect the missing dot from an "i"

• Scale makers have borrowed a new kind of alloy used for springs in the finest watches—metal far springier than the finest steel. We call it Nilcor* . . . and produce it in widths from ⅛" to 1⅜", .0025" to .025" thick.

It's so hard and tough that only the finest, most advanced mill equipment and techniques can process it. Yet it is the most perfect material known for making the precision torsion bands used in laboratory scales . . . with more precise characteristics . . . greater stability . . . unmatched resistance to corrosion . . . longer life under repetitive bending.

Despite the difficulty of working Nilcor, the *Athenia Steel Division* of National-Standard gives it up to an 85% reduction and maintains tolerances as close as .0001".

It is this kind of ability that enables Athenia to develop practical applications of unique Nilcor and also makes Athenia a foremost supplier of special high carbon strip steel.

If you think you have a particular application requiring Nilcor, or if you need strip steel with unusual demands for tolerance, flatness, edge forming, uniformity, temper and other characteristics, try *Athenia*. And remember, small company or big company, we are eager to serve you. Write us.

*Trade Mark, National-Standard Company.

NS NATIONAL-STANDARD Company NILES, MICHIGAN

NATIONAL-STANDARD COMPANY • NILES, MICHIGAN
Tire Wire, Stainless, Fabricated Braids and Tape
ATHENIA STEEL DIVISION • CLIFTON, N. J.
Flat, High Carbon, Cold Rolled Spring Steel
REYNOLDS WIRE DIVISION • DIXON, ILLINOIS
Industrial Wire Cloth
WAGNER LITHO MACHINERY DIVISION • JERSEY CITY, N. J.
Special Machinery for Metal Decorating
WORCESTER WIRE WORKS DIVISION • WORCESTER, MASS.
Round and Shaped Steel Wire, Small Sizes

Quality components

MAKE GOOD PRODUCTS EASIER TO SELL

...so in advertising and literature, these machinery builders feature

✓BLOOD BROTHERS Universal Joints and Drive Lines

Doctor, Merchant or Chief Engineer, you learn to prefer well-known products of high reputation—whether tires for your family car or component parts for your products.

These farm machinery manufacturers, too, have learned from past satisfaction that customers *respect and prefer to buy* implements with Blood Brothers Universal Joints.

So in catalogs and advertising, they *voluntarily* feature the dependable, uniform high quality of Blood Brothers Drive Lines.

Engineer, Purchasing Agent or Salesman—*you'll* find good products get extra preference (and perform better too) when they're Blood Brothers' equipped!

Write for engineering data and "Spec Sheet" Blanks.

BLOOD BROTHERS MACHINE DIVISION

ROCKWELL SPRING AND AXLE COMPANY
ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

ALTERNATIVE TO DISASTER . . . fire-resistant oils

Celanese* Cellulubes* are synthetic oils—straight chemical compounds developed by Celanese to minimize the constant threat of fire and explosions inherent in many industrial operations.

As power transfer fluids in diecasting and other critical hydraulic operations, fire-resistant Cellulubes reduce the ever-present danger of uncontrollable fires due to line breaks or other failures. As cylinder lubricants in air compressor systems, these non-petroleum oils prevent the formation of excessive carbon deposits. Result: danger of fires and explosions is minimized and maintenance costs reduced.

Can a Cellulube solve a safety problem in one of your plants? We will be glad to send you complete use data.

Cellulube fire-resistant functional fluids are the result of research working toward a single objective: how to give industry more productive chemical materials. If you're looking for the extra values that can make your operation safer, your production more efficient, or your product more competitive, we think you'll find the Celanese research approach rewarding. Celanese Corporation of America, Chemical Division, Dept. 598-F, 180 Madison Avenue, New York 16, N. Y.

Basic reasons . . . . . .

Acids
Alcohols
Aldehydes
Anhydrides
Esters

Functional Fluids
Gasoline Additives
Glycols
Ketones
Oxides

Polyols
Plasticizers
Salts
Solvents
Vinyl Monomers

Celanese* CHEMICALS

*Reg. U.S. Pat. Off.

. . . . . for improved products

Agricultural, automotive, aviation, building, electrical, paper, pharmaceutical, plastics, surface coatings, textile.

SPECTOR...Chicago's largest... standardizes on Fuller ROADRANGERS®

Spector Freight Systems, Inc., largest common carrier with home offices in Chicago, is adding 104 new tractors equipped with R-46 ROADRANGERS to bring a total of 257 ROADRANGER equipped tractors to its fleet.

Referring to Spector's 149 tractors now equipped with Fuller 8-speed ROADRANGERS, to 4 tractors equipped with 10-speed ROADRANGERS . . . and to the 104 new units with 8-speed Model R-46 ROADRANGERS, C. L. Lunt, Vice President, Operations, says:

"We have standardized on the ROADRANGER Transmission for better over-all fleet performance and less maintenance . . . resulting, of course, in a substantial dollar savings. Also, our drivers overwhelmingly prefer the semi-automatic Fuller ROADRANGER Transmission."

Spector, whose gross revenues rose from $1½-million in 1945 to an estimated $21-million in 1955, *knows* the value of better over-all fleet performance. Spector drivers prefer ROADRANGER 8 and 10-speed Semi-Automatic Transmissions with:

C. L. Lunt, Vice President, Operations

- **Easier, quicker shifts—all forward speeds in short closely spaced steps between ratios**
- **One shift lever that controls all forward speeds**
- **No gear splitting—all selective gear ratios are evenly and progressively spaced**
- **Higher average road speeds—engines operate in peak hp range with greater fuel economy**
- **Less driver fatigue—⅓ less shifting**
- **Range shifts pre-selected—automatic and synchronized**

• • •

Compact space-and-weight-saving economies permit more cargo to be carried on payload axles. Get full facts on ROADRANGER from your truck manufacturer or truck dealer, now!

FULLER MANUFACTURING COMPANY
TRANSMISSION DIVISION • KALAMAZOO, MICH.

Unit Drop Forge Div., Milwaukee 1, Wis. • Shuler Axle Co., Louisville, Ky. (Subsidiary) • Sales & Service, All Products, West. Dist. Branch, Oakland 6, Cal. and Southwest Dist. Office, Tulsa 3, Okla.

LONG

LONG B-W BORG-WARNER

Long's expansion of facilities and personnel was motivated by the extension of our products to new fields and new applications.

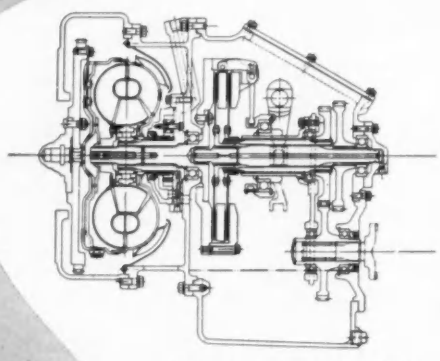
Our emphasis on the development of our manufacturing and engineering services to industry can serve you in the most practical manner—through paring costs and delivery dates.

Long experts stand ready to design and build in volume, products with a savings potential for you.

LONG MANUFACTURING DIVISION, BORG-WARNER CORPORATION

12501 DeQuindre Street, Detroit 12, Michigan

Also: Windsor and Oakville, Ontario



Torque Converter with Power Shifting forward and reverse gearing.

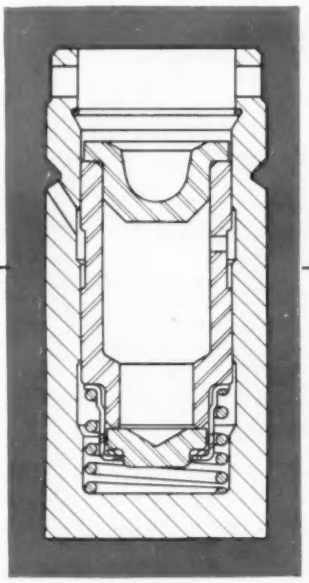
"Power Package"
TORQUE CONVERTER COMBINATIONS

Accurately engineered to your own power transfer requirements, B-W torque converter transmission combinations provide extra rugged construction, reduced maintenance costs, greatly improved performance. Now available in package form are any of the Borg-Warner volume production drive line products . . . a wide variety of torque converters • transmissions • industrial and agricultural clutches • power takeoff and speed reducers • and many other "Power Package" combinations.

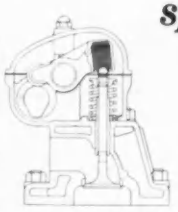
THE STANDARD OF QUALITY AND PERFORMANCE SINCE 1903

Designing valve gear?

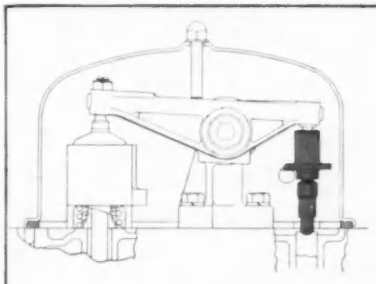
We invite you to use these specialized CHICAGO services



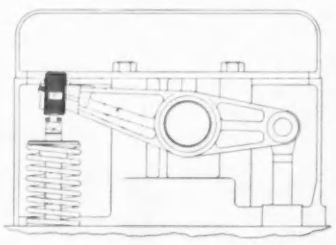
CHICAGO SPRING-LOADED FLAT VALVE HYDRAULIC TAPPET



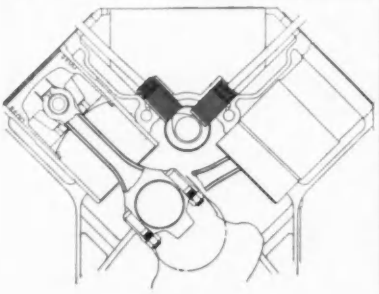
INSERT TYPE ROCKER ARM UNIT



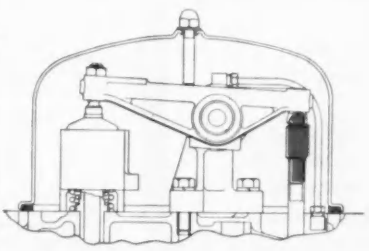
PUSH ROD TYPE FOR COMPRESSION RELEASE APPLICATION



THREADED TYPE ROCKER ARM UNIT



V-8 AUTOMOTIVE HYDRAULIC TAPPET APPLICATION



HYDRAULIC UNIT ON END OF PUSH ROD

Design

of complete valve gear installations for any type of engine . . . passenger car, truck, tractor, diesel, aircraft or industrial.

Development engineering

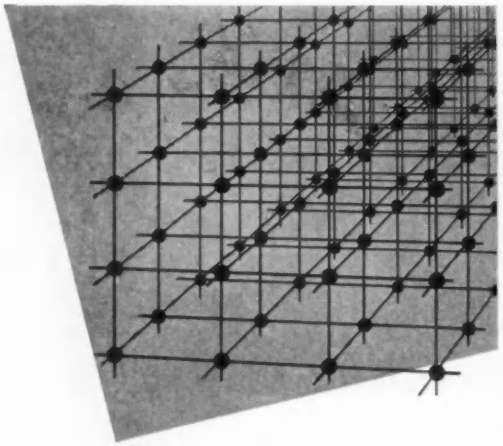
based on years of specialized experience in valve gear problems. The skills of our engineers will prove a valuable addition to your own engineering staff.

Tappet manufacturing

CHICAGO's facilities insure precision-manufacturing, scientific testing and rugged, trouble-free performance in every tappet. We will welcome the opportunity to serve you.

CHICAGO

THE CHICAGO SCREW COMPANY
Division of Standard Screw Company
252 Washington Blvd., Bellwood, Ill.
Established 1872



nuclear CAREERS for

SCIENTISTS and ENGINEERS

At COMBUSTION ENGINEERING'S new Nuclear Engineering and Development Center, Windsor, Connecticut, permanent openings for SENIOR AND JUNIOR POSITIONS are available to qualified

Aeronautical Engineers	**Mechanical Engineers**
Chemical Engineers	**Metallurgists**
Chemists	**Naval Architects**
Design Engineers	**Nuclear Engineers**
Electrical Engineers	**Physicists**
Mathematicians	**Structures Engineers**

Here is your opportunity to help develop a new NAVAL NUCLEAR PROPULSION SYSTEM—with the first company in the country that will complete such an AEC contract with its own facilities.

You will be a member of a company that is well-established in the Nuclear Power field. Combustion Engineering has accumulated ten years' experience—designing and building major reactor components, both for Naval units and for central stations.

And you'll find Windsor a wonderful place to live. Only 8 miles from Hartford, it is an ideal location, both for work and for play.

If you are a citizen, whether you have Nuclear experience or not—send a complete resume, in strict confidence, to B-921

COMBUSTION ENGINEERING, INC.

Reactor Development Division • Department D, Windsor, Conn.

THERMAL RESISTANCE...CHEMICAL RESISTANCE!

Now available
DACRON • ORLON
NYLON • ARNEL
ACRILAN • DYNEL

These new American Synthetic Felts have exceptional *chemical resistance* with *thermal stability* to 300 F. They are non-hygroscopic, biologically stable and are available in a complete range of thicknesses. Precision engineering assures close density control and extremely close thickness tolerances.

Let American's engineering and research staff help you determine which felt is best for your job.

WRITE TODAY!

American Felt Company

TRADE MARK

GENERAL OFFICES: P. O. BOX 5, GLENVILLE, CONN.

Engineer, Design

ADVANCED DESIGN GROUP

AIRCRAFT NUCLEAR PROPULSION PROJECT

At General Electric's ANP Department esprit de corps is part of the work-environment. This is because the application of nuclear power for aircraft propulsion offers the qualified engineer the opportunities for personal achievement that go with professional challenge.

A responsible position is now open for an engineer interested in this field: must have an engineering degree, several years diversified experience in analysis and design of power plant components, including design of nuclear reactors. The job carries the responsibility for preliminary design analysis of power plants, and directing completed scale design and layout drawings of power plants and equipment.

Publication of research results in the appropriate classified or open literature is encouraged.

OPENINGS IN CINCINNATI, OHIO AND IDAHO FALLS, IDAHO

Address replies stating salary requirements to location you prefer

W. J. KELLY
P. O. Box 132
Cincinnati, Ohio

L. A. Munther
P. O. Box 535
Idaho Falls, Idaho

GENERAL ELECTRIC

XV

This is the fifteenth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Boron and Its Effects in Alloy Steels

Boron is a nonmetallic element of which this country has a plentiful supply. In its natural or unprocessed state it occurs only in combination, as in borax, etc. Pure boron is a gray, extremely hard solid with a melting point in excess of 4000 deg F.

This element is used in steel for one purpose only—to increase hardenability; that is, to increase the depth to which the steel will harden when quenched. Its effective use is limited to sections whose size and shape permit of liquid quenching. Only a few thousandths of 1 pct is ordinarily added, and boron steels are evaluated by increased hardenability rather than chemical content. A number of alloys, including several grades of ferroboron, are available for adding boron to steel.

Boron intensifies the hardenability characteristics of other elements present in the steel. It makes possible a considerable degree of alloy conservation when used with steels containing small amounts of alloying elements. However, since it readily oxidizes at high temperatures, some steelmakers prefer a melt with relatively low boron content and relatively high contents of other elements that protect the boron from oxidation.

It should be noted that boron is very effective when used with low-carbon alloy steels; but its effect is reduced as the carbon increases. When the carbon content is above 0.60 pct, the use of boron is not suggested, the exception being the "case" in those steels that are carburized.

Boron steels often require closer temperature control in heat-treatment than do some of the other alloy analyses; but aside from this they present no special problems. Their cold- and hot-working properties are considered at least equal to those of ordinary alloy steels. In cases where boron makes possible a lower alloy content, improved machinability frequently results.

If you would like to know more about boron and its effects in alloy steels, you are invited to consult with Bethlehem's metallurgical staff. Our technicians will gladly give you all the information you need, and will work closely with you in every respect. And when it is time to replenish supplies of steel, remember that Bethlehem manufactures the full range of AISI standard alloy grades, as well as special-analysis steels and all carbon grades.

If you would like a reprint of this advertisement, or of the entire series from I through XV, please write to us, addressing your request to Publications Dept., Bethlehem Steel Company, Bethlehem, Pa.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Weight-saving frameless type van built of chromium-nickel stainless steel retains impressive beauty of silvery white metal despite wear and tear of travel. Deadweight reduction holds down operating and maintenance costs for Piedmont Mountain Freight Lines, of Charlotte and North Wilkesboro, North Carolina. Van produced by Black Diamond Trailer Co., Inc., Bristol, Va.

Stainless steel adds capacity, yet cuts weight

THE BODY of this 32-foot trailer is fabricated from Type 301 chromium-nickel stainless steel.

High mechanical properties of Type 301 helped the designer dispense with the frame, and reduce deadweight, yet increase over-all strength of the van.

As a result, the unit carries additional payload without a corresponding increase in axle loading. But this isn't the only advantage afforded by stainless steel.

The good forming and welding qualities of Type 301 permit swift, simplified fabrication, and make it easy to strengthen the sides with an integral-column ribbed construction offering exceptional resistance to side-bulging.

Particularly important to body-builders, stainless steels containing nickel provide not only high strength, but also ample toughness to withstand impact and battering, wear and abrasion. Resistant to corrosive attacks of rain, sleet, ice and atmosphere, these steels retain their silvery white beauty and remain easy to clean and keep clean.

Where you want long, money-saving performance, put stainless steel on the job. Leading steel companies produce austenitic chromium-nickel stainless steels in all commercial forms. We'll be glad to help you select exactly the right type of stainless for your specific needs. Send us details of your application for our suggestions.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N.Y.

The ring of quality

Colorful, low-cost sidewall rings that can be quickly installed on tires are now contributing to the luxury-look of today's new cars. They're inexpensive, stay brilliant for life, wash bright in seconds, out-last tires. A product of The Bearfoot Sole Co., Wadsworth, Ohio, these rings are available in a variety of colors or in white. They're made of Enjay Butyl Rubber because no other rubber tested could equal its performance in severe laboratory and road tests. The Enjay Butyl label on the Flex-A-Wall® carton assures the buyer of outstanding quality.

Find out for yourself the many technical advantages of Enjay Butyl—the rubber that is outperforming natural and other types of rubber in a wide variety of industrial and consumer applications. For full information, and for technical assistance in the use of Enjay Butyl, write, wire or phone the Enjay Company.

ENJAY BUTYL

ENJAY *Pioneer in Petrochemicals*

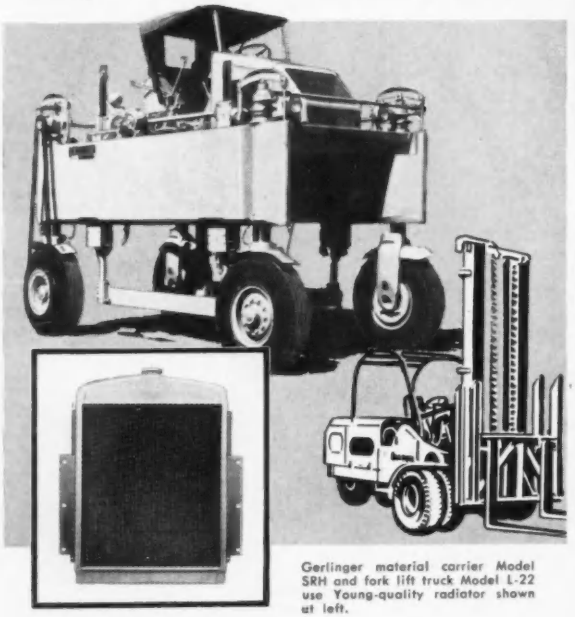
ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Other offices: Akron • Boston • Chicago • Los Angeles • Tulsa

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

Young Radiators

cool the engines that power the "muscles" of Gerlinger weight lifters and carriers



Gerlinger material carrier Model SRH and fork lift truck Model L-22 use Young-quality radiator shown at left.

Young engine-cooling radiators tailored for every automotive application

Young radiators are used wherever the going is tough. So, when a Gerlinger material carrier loads up with 30,000 lbs., or a fork lift truck hoists and maneuvers a half dozen or more tons, powerful engines have to be kept cool! Here is where Young radiators prove their quality. On Gerlinger equipment, as well as on many others, Young radiators provide the specific answers to heat transfer problems. Patented features insure maximum heat transfer and give Young cores a dependable ruggedness. In the automotive field Young produces radiators to cool lube oil or torque converter fluid and engine jacket water.

Put Young Talent to work for you . . .

Solving heat transfer problems is what we do best because it is our very reason for being. You, too, can harness the power of Young engineering talent. Write, wire or call without obligation.

Write Dept. F-116 for FREE Catalog

Young RADIATOR COMPANY

RACINE, WISCONSIN

Creative HEAT TRANSFER ENGINEERS FOR INDUSTRY

Heat Transfer Products for Automotive, Aviation and Industrial Applications. Heating, Cooling, Air Conditioning Products for Home and Industry.

Executive Office: Racine, Wisconsin, Plants at Racine, Wisconsin, Mattoon, Illinois

ENGINEER

RECOGNIZED SPECIALIST

Aircraft Propulsion Turbine Design

You can make a substantial contribution to jet engine and rocket design if you have experience on single and multi-staged turbines. Your high temperature application experience will help the Aircraft Gas Turbine Division of General Electric resolve advanced design problems in temperature gradient and stress pattern difficulties. You'll be asked to create turbine bucket locking methods, and solve problems in stress, vibration and material selection.

You'll be associated with top experts in the field, working in the kind of professional climate that your creative talents really deserve. All-inclusive benefit program. High starting salary.

Please send resume to:

Mr. Mark Peters
Technical Recruiting Building 100
Aircraft Gas Turbine Division

GENERAL ELECTRIC

Cincinnati 15, Ohio

Imperial

the world's finest

TRACING CLOTH

In drafting rooms throughout the world Imperial quality is the standard by which fine tracing cloths are judged. This has been true for decades, and Imperial remains the finest tracing cloth because its makers have continued to improve its quality and value.

Sealed Power
CHROME-FACED
Cyclan
PISTON RINGS
deliver unequalled performance!

These rings combine the break-proof qualities of Cyclan with the heat-resistance and wear-resistance of chrome. They are already being used by many Diesel engine builders, with amazing results.

SEALED POWER CORPORATION • MUSKEGON, MICH. • ST. JOHNS, MICH. • ROCHESTER, IND.
DETROIT OFFICE • 7-236 GENERAL MOTORS BLDG. • PHONE TRINITY 1-3440

Sealed Power Piston Rings
PISTONS • CYLINDER SLEEVES
Leading Manufacturer of Automotive and Industrial Piston Rings since 1911
Largest Producer of Sealing Rings for Automatic Transmissions • Power Steering Units

Over 85% of the torque wrenches used in industry are

Sturtevant
TORQUE WRENCHES

Read by Sight, Sound or Feel

- Permanently Accurate
- Practically Indestructible
- Faster—Easier to use
- Automatic Release
- All Capacities

in inch grams
...inch ounces
...inch pounds
...foot pounds

Every manufacturer, design and production man should have this valuable data. Sent upon request.

P.A. Sturtevant Co.
ADDISON QUALITY ILLINOIS

WITTEK HOSE CLAMPS
For Every Type of Hose Connection

Whatever the hose connecting problem, it's a safe bet that WITTEK (leader for over a quarter century) has the *exact* type and size clamp to do the job right! Let WITTEK solve *your* clamping problems. Write today.

WITTEK MANUFACTURING CO.
4342 West 24th Place • Chicago 23, Illinois

LET TURNERS IN BRITAIN MAKE IT FOR YOU!

Do you wish to establish manufacture in the United Kingdom to trade with sterling area countries?

Since 1906, The Turner Manufacturing Company has specialized in accurate machining and assembly. Over 180,000 square feet of factory space available, equipped with the most up-to-date precision tools, and staffed by skilled craftsmen.

Ample financial and production resources are at your disposal. WRITE NOW.

TURNER MANUFACTURING CO. LTD.
LEVER STREET, WOLVERHAMPTON, ENGLAND

Want One For Your Lapel?

An SAE Emblem

- Distinguishes you as an SAE member
- Is an attractive gold-filled clutch-back pin
- Costs only $1.50
  plus
  15¢ Federal tax for delivery in the United States and 5¢ sales tax for delivery in New York City

ACTUAL SIZE

GOLD on BLUE ..... Member Grade
GOLD on RED ..... Associate Grade
GOLD on WHITE ..... Junior Grade

Society of Automotive Engineers
29 West 39 St., New York 18, N. Y.

Please send me an SAE emblem. Enclosed is my check for $..... ($1.50 plus applicable taxes). Grade of membership (please check)

☐ Member ☐ Associate ☐ Junior

Name .....
(PLEASE PRINT)

Address .....

Champion

BY MILSCO

BODY-FORM POSTURE DESIGN FOR IMPROVED WORK-POWER

Designed to improve the road-ability and comfort-factor of many types of mobile equipment. Full cushion roomy seat equipped with permanently aligned synchronized "no-sag" springs and foam rubber topper. Contour back rest deeply cushioned with foam rubber and jute felt. Snap-on detachable arm rests add to operating comfort and seat versatility. Ball type seat adjuster with finger-lift handle. Get the complete facts on this popular Milsco "Champion" . . . one of the finest cushion seating products of our more than quarter century experience.

SOLD ONLY TO MANUFACTURERS OF ORIGINAL EQUIPMENT

NO. F850 Full Cushion Seat

Milsco MILWAUKEE

DETACHABLE Snap-On Arm Rest
HALF-INCH BALL TYPE SEAT ADJUSTER
NO-SAG SPRINGS WITH FOAM RUBBER
SOLID TUBULAR STEEL FRAME

MILSCO MANUFACTURING COMPANY, 2758 N. 33RD STREET, MILWAUKEE 45, WIS.

WHERE IN THE WORLD DO YOU WANT TO GO IN YOUR ENGINEERING CAREER?

If you are seeking an opportunity to further your career with a fine company . . . look no further.

TWA presently has openings for Aeronautical, Mechanical, Electrical and Electronic Engineers to work with a small, select group of engineering associates. This arrangement gives each engineer the opportunity to demonstrate his ability and to advance within the company . . . the opportunity to build his future with the world's finest airline.

Qualifications: B.S. in Engineering.

Location: TWA's ultra modern building now nearing completion at Kansas City, Mo.

Living Conditions: Excellent, both city or suburban private homes or apartments.

Benefits: Many employee benefits, including liberal free transportation for yourself and family each year.

Salary: Commensurate with experience.

If you are an engineer with qualifications in any of these fields, explore your opportunity with TWA today. Write:

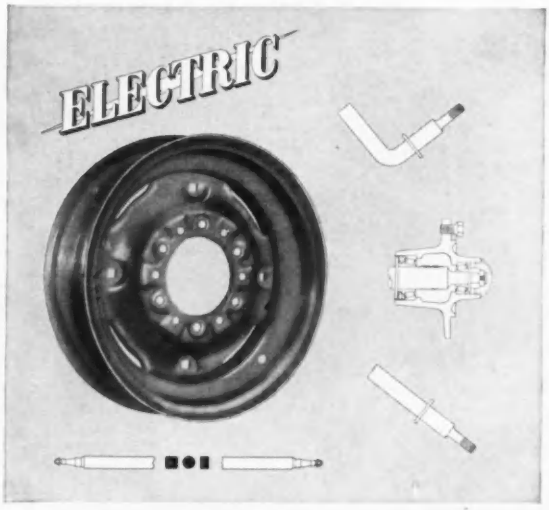
Mr. Paul Day, Employment Manager
TRANS WORLD AIRLINES
Kansas City 5, Missouri

VELLUMOID

What about "BEATER MIX" Gasket Materials?

- The "beater mix" process is not in itself a guarantee of superior performance.
- A gasket must first of all *seal*. For many applications it must be oil or fuel resistant. On all applications it must never deteriorate in service.
- VELLUMOID'S VELBUNA WG-1 and WG-4 beater mix Buna N and fibre gaskets *seal*. They are oil resistant, have high torque retention and work effectively on applications where firm, dense materials at reasonable cost are required.
- Send for sample gaskets for testing on your own applications. The Vellumoid man in your territory is always available for consultation.

VELLUMOID COMPANY
56 ROCKDALE ST. · WORCESTER, MASS.



A Wheel for Every Job!

Our engineers will recommend the most efficient and economical wheel and axle assembly for your unit. We invite your inquiries.

WRITE US FOR CATALOG
ELECTRIC WHEEL CO.
2807 SPRUCE, QUINCY, ILLINOIS

NOW AVAILABLE

AERONAUTICAL INFORMATION REPORTS ON AIRCRAFT GREASES (DATED MARCH 1, 1955)

AIR No. 39, WATER COMPATIBILITY OF AIRCRAFT GREASES $0.50

AIR No. 40, CORROSION PREVENTIVE CHARACTERISTICS OF AIRCRAFT GREASES $0.75

AIR No. 41, STABILITY OF AIRCRAFT GREASES $0.50

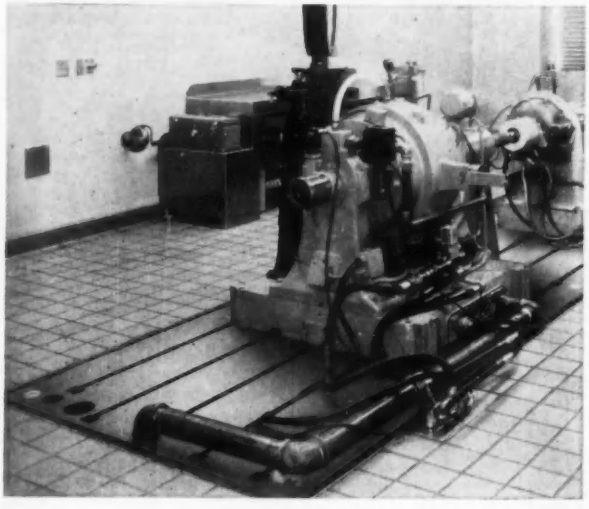
AIR No. 42, CONTAMINATION STUDIES OF AIRCRAFT GREASES $0.50

AIR No. 43, LOW TEMPERATURE TORQUE TEST FOR AIRCRAFT GREASES $1.00

AIR No. 44, LOAD SUPPORT CHARACTERISTICS OF AIRCRAFT GREASES $1.00

SOCIETY OF AUTOMOTIVE ENGINEERS, Inc.
29 WEST 39th ST., NEW YORK 18, N. Y.

The auto makers have the answer . . .



—TO ACCURATE DYNAMOMETER TESTS

Automobile manufacturers depend on Lake Shore bases for accurate dynamometer tests. These bases, which are standard equipment in auto manufacturers' testing and development sections, are specifically designed by Lake Shore for precise testing. They serve as a "true" reference . . . facilitate testing control . . . and eliminate unnecessary vibrations.

Cast of fine-grained, flaw-free "Lakenite" iron, these plates have the strength and rigidity to stand up indefinitely under severe testing conditions. For further details and specifications send for your free copy of Lake Shore's new eight page illustrated base plate booklet.

LAKE SHORE, Inc.
Lake Shore Engineering Division
IRON MOUNTAIN 8, MICHIGAN

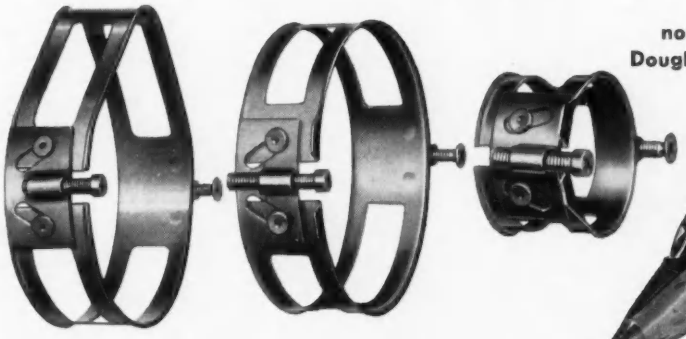
Please send me a free copy of the new eight page illustrated Lake Shore base plate booklet.

Name_____
Title_____
Company_____
Address_____
City_____

MARMAN ANNOUNCES NEW TIME-SAVING

Lightweight Instrument Clamps

PATENT APPLIED FOR

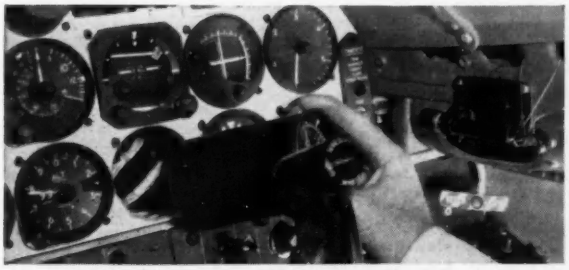


now used on the
Douglas A4D Skyhawk

Marman AN instrument mount clamps are designed to attach most instruments to aircraft instrument panels. Special sizes and configurations are also available.

- **Full AN approval in 1½", 2" and 3¼" sizes**
- **60% weight savings over standard instrument clamps**
- **Designed for quick, easy installation and removal**
- **Fit 1/16" to ¼" instrument panels without adjustment**
- **Instrument weight supported by both clamp screws**
- **Eliminate instrument panel warping**
- **Entirely non-magnetic for universal application**
- **Immediate delivery in AN-approved sizes**

Write, wire or call for full information and prices



For ease of installation, expanded clamp is placed behind instrument panel and attached with two screws. Instrument is then inserted into panel.

Cam action on master screw tightens the clamp around the instrument. When installation is complete, instrument is locked securely in place.

MARMAN PRODUCTS COMPANY, INC.

A SUBSIDIARY OF Aeroquip CORPORATION

11214 EXPOSITION BLVD., LOS ANGELES, CALIFORNIA

IN CANADA: AEROQUIP (CANADA) LTD., TORONTO 15, ONTARIO

MARMAN PRODUCTS ARE MANUFACTURED UNDER VARIOUS U.S., CANADIAN AND FOREIGN PATENTS AND OTHER PATENTS PENDING

SAE offers the...

SHOT PEENING MANUAL

SP-84

● A "HOW-TO-USE-IT" BOOK—
SAE Shot Peening Manual, the work of Division XX—Shot Peening, Iron & Steel Technical Committee, instructs engineers, designers, and shop men in shot peening "know how."

● A FIRST COMPLETE STORY—
the Manual fully discusses shot, shot peening machines, production procedures and process specifications; includes 29 illustrations and a bibliography of 50 selected references.

● A BRAND NEW SAE MANUAL—
the Shot Peening Manual—SP-84, newly listed with our publications, is priced at $2.00 per copy to SAE members and $4.00 per copy to nonmembers; quantity prices upon request.

ORDER BLANK

Society of Automotive Engineers
29 West 39th Street
New York, New York

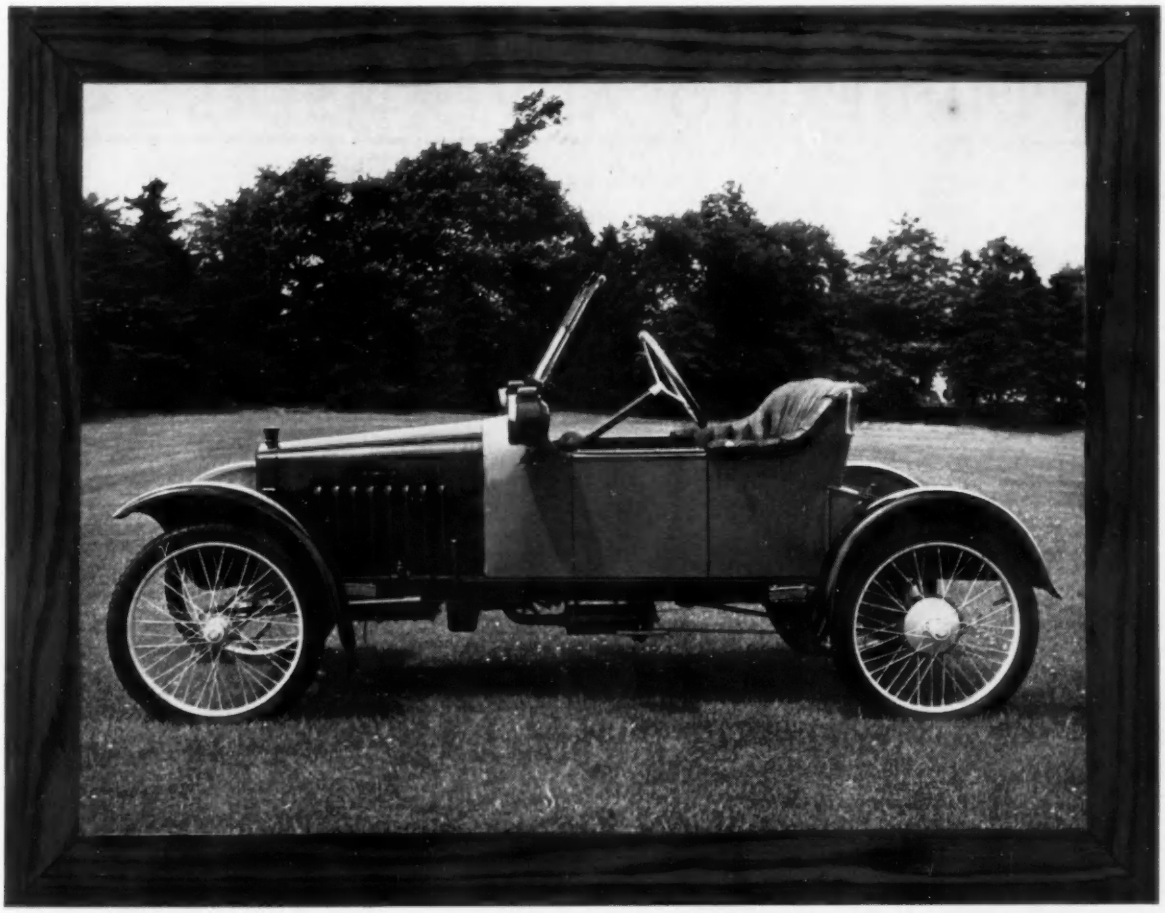
Add 3% city sales tax for deliveries in N. Y. C.

Please send me .... copies of SP-84. (Check) (Cash) (Coupons)

Name _____

Company Name _____

Company Address _____



Send for free print—1914 Saxon Runabout, Model A.
Reprinted by permission—P. S. de Beaumont; not for commercial use.

At $395, the 1914 Model A Saxon Runabout was called "the poor man's light car." It had a 96-inch wheelbase, two-speed transmission, and featured standard tread wheels instead of the very narrow ones then in vogue on cyclecars.

This is one of a series of antique automobile prints that will appear in future Morse advertisements. Write for your free copy, suitable for framing. Morse Chain Company, 7601 Central Avenue, Detroit 10, Michigan.

18 out of 22 automobile manufacturers specify Morse Timing Chain Drives

Ever since mechanical horsepower began replacing nature's variety, the Morse Chain Company has supplied the auto industry with its precision-built Timing Chain Drives.

Fact is that today, eighteen out of the twenty-two automotive manufacturers using timing chains, actually *specify* Morse Chain Drives as original equipment.

More than 60,000,000 of these drives have already gone into cars, trucks, and buses—giving vehicle owners long service life, plus freedom from maintenance worries. Morse Timing Chains operate safely, quietly, and smoothly—with positive timing.

Investigate Morse Timing Chain Drives . . . and the other precision-built power transmission products which Morse manufactures. We have expert engineers always available to help you in your power transmission requirements. Write, wire, or phone us, today, for quick assistance on your particular problem.

MORSE CHAIN COMPANY: DETROIT, MICHIGAN; ITHACA, NEW YORK.

MORSE MORSE BW •trademark **POWER TRANSMISSION PRODUCTS**

+ INDEX TO ADVERTISERS +

A

Acro Switch Div., Acro Mfg. Co. 111
AC Spark Plug Div., General Motors Corp. 183
Aetna Ball & Roller Bearing Co., Div. of Parkersburg-Aetna Corp. 117
AiResearch Manufacturing Co. 115
Aluminum Co. of America 10
American Felt Co. 218
Ampex Corp. 178, 179
Arabian American Oil Co. 231
Auto Radiator Mfg. Co. 130
Auto Specialties Mfg. Co., Inc. 143

B

Baldwin-Lima-Hamilton Corp. 116
Bendix Aviation Corp.
Products Div. (General Sales) 16
Eclipse Machine Div. 161
Bethlehem Steel Co. 164, 219
Blood Brothers Machine Co. 213
Bohn Aluminum & Brass Corp. 171
Borg-Warner Corporation 133
Borg & Beck Division, Borg-Warner Corp. 138
Bower Roller Bearing Div. 209
Bundy Tubing Co. 186, 187

C

California Institute of Technology, Jet Propulsion Laboratory 192
Carter Carburetor Corp. 139
Celanese Corp. of America 214
Century Electronics & Instruments, Inc. 125
Chicago Rawhide Mfg. Co. 6
Chicago Screw Co. 217
Clark Equipment Co. 144
Cleveland Pneumatic Tool Co. 196
Cleveland Steel Products 129
Cleveland Welding Div., American Machine & Foundry Co. 167
Combustion Engineering, Inc. 218
Crucible Steel Co. 9

D

Dana Corp. 180, 181
Delco-Remy Division, General Motors Corp. 156, 157
Detroit Controls Corp. 148
Dole Valve Co. 126
Douglas Aircraft Co., Inc. 166

E

Eaton Mfg. Co., Valve Div. 14
Elastic Stop Nut Corp. of America 211
Electric Auto-Lite Co. 176
Electric Wheel Co. 226
Enamelstrip Co. 162, 163
Enjay Co., Inc. 221
E. N. V. Engineering Co. Ltd. 7
Esso Standard Oil Co. 172, 173
Evans Products Co. (Heating & Ventilating Div.) 201

F

Fabricon Products, Inc. 114
Fafnir Bearing Co. Inside Back Cover
Fairchild Engine & Airplane Corp., Aircraft Div. 199
Fasco Industries, Inc. 120
Fasteners, Inc. 146
Federal-Mogul Div. 165
Firestone Steel Products Co. 151
Fuller Mfg. Co. 215

G

Gardner-Denver Co. 204
Garlock Packing Co. 134
General Electric Co. 218, 222, 231
General Plate Division, Metals & Controls Corp. 12
Goodyear Tire & Rubber Co., Inc. (Metal Products Div.) 158, 159
Graton & Knight Co. 182
Great Lakes Steel Corp. 232

H

Harrison Radiator Division, General Motors Corp. 113
Heim Co. 152
Hooker Electrochemical Co. 141
Hunter Douglas Aluminum Corp. 137

I

Imperial Brass Mfg. Co. 155
Imperial Pencil Tracing Cloth 222
International Nickel Co., Inc. 220
International Packings Corp. 182

J

Jack & Heintz, Inc. 121
Johns-Manville Corp. 203
Johnson Bronze Co. 177
Johnson Products, Inc. 112

K

Keuffel & Esser Co. 128

L

Lake Shore, Inc. 226
Lisle Corp. 140
Lockheed Aircraft Corp. 191
Missile Systems Div. 174
Long Mfg. Division, Borg-Warner Corp. 216

M

McLouth Steel Corp. 154
Magnaflux Corp. 170
Marman Products Co., Inc. 227
Marquardt Aircraft Co. 122
Martin, Glenn L. Co. 2
MB Manufacturing Co., Inc. 200
Mechanics Universal Joint Div., Borg-Warner Corp. 149
Micromatic Hone Corp. 184
Midland Steel Products Co. 150, 195
Milsco Mfg. Co. 225
Morse Chain Co. 229
Muskegon Piston Ring Co. 135

N

National Motor Bearing Co., Inc. 11
National Standard Co. 212
New Departure Division, General Motors Corp. 1
North American Aviation, Inc.
Downey Missile Engineering 127
Rocketdyne Division 202

P

Palnut Co. 132
Park Drop Forge Co. 110
Parker Rust Proof Co. 160
Perfect Circle Corp. Inside Front Cover
Precision Rubber Products Corp. 3
Purolator Products, Inc. 194

R

Raybestos-Manhattan, Inc. Plastics Products Div. 5
Rockford Clutch Division, Borg-Warner Corp. 142
Rohr Aircraft Corp. 210
Ryan Aeronautical Co. 153

S

Saginaw Steering Gear Division, General Motors Corp. 145
A. Schrader's Sons 188
Sealed Power Corp. 223
SKF Industries, Inc. 123
Southwest Products Co. 198
Stackpole Carbon Co. 136
Standard Electric Time Co. 118
Sterling Aluminum Products, Inc. 4
Sturtevant Co., P. A. 224

T

Taylor Dynamometer & Machine Co. 110
Tennessee Valley Authority, Division of Materials 231
Timken Detroit Axle Division Rockwell Spring & Axle Co. 168, 169
Timken Roller Bearing Co. Outside Back Cover
The Torrington Co. (Needle Bearings) 207
Trans-World Airlines 225
Tung-Sol Electric, Inc. 131
Turner Mfg. Co. Ltd. 224

U

United-Carr Fastener Corp. 208
U. S. Rubber Co., Naugatuck Chemicals 185, 205, 231
Upholstery Leather Group 190

V

Veedor-Root, Inc. 189
Vellumoid Co. 225
Vickers, Inc., Division of Sperry Rand Corp. 193
Victor Mfg. & Gasket Co. 197

W

Wagner Electric Corp. 206
Waldes Kohinoor, Inc. 175
Weatherhead Co. 147
Western Felt Works 8
Wittek Mfg. Co. 224
Wyman-Gordon Co. 119

Y

Yates-American Machine Co. 124
Young Radiator Co. 222

AUTOMOTIVE ENGINEER

Graduate M.E. with minimum 5 years' experience involving design, selection or preparation of specifications for the construction and use of heavy, medium and light off-road automotive equipment. For work in Company's Equipment Engineering Department. Will prepare specifications for manufacture, economic and engineering analysis for selection and guidance for tests and inspection of purchased equipment.

AUTOMOTIVE ENGINEER JR

Foreign Employment

Recent graduate with limited or no work experience. For Company's training program in Saudi Arabia.

Salary commensurate with qualifications.

Write outlining personal history and work experience. Please include telephone number.

Recruiting Supervisor, Box 133
ARABIAN AMERICAN OIL COMPANY
505 Park Avenue, New York 22, New York

---

engineer
ME, AE

Design Mechanical Portions of Aircraft Nuclear Power Plant Equipment

General Electric now offers the qualified engineer a rare opportunity to combine good judgment, sound engineering fundamentals and the ability to work with others. This is a career position in one of the latest aeronautical areas, aircraft nuclear propulsion. The working environment is excellent . . . the personal benefits, comprehensive.

The engineer who qualifies for this job will be responsible for the design and proper functioning of the mechanical portions of power plant equipment associated with both engines and reactors. This means he must have 3 to 8 years' experience in the mechanical design of lightweight, high temperature machinery, preferably experience in turbojet engines. An advanced degree is desirable.

OPENINGS IN CINCINNATI, OHIO AND IDAHO FALLS, IDAHO

Address Replies stating salary requirements to Location You Prefer . . .

W. J. Kelly
P. O. Box 132
Cincinnati, Ohio

L. A. Munther
P. O. Box 535
Idaho Falls, Idaho

GENERAL ELECTRIC

MECHANICAL ENGINEERS

ENGINEERING GRADUATES FOR PRODUCT DESIGN AND APPLICATION. PRODUCTS ARE VIBRATION AND SHOCK ISOLATION SYSTEMS ON AIRCRAFT, ELECTRONIC, AUTOMOTIVE, MARINE, GENERAL INDUSTRIAL EQUIPMENT. THIS IS A RAPIDLY EXPANDING INDUSTRY. EXCELLENT LONG RANGE POSSIBILITIES FOR ENGINEERS WHO ARE INTERESTED PRIMARILY IN DESIGN WORK. DUTIES ALSO INVOLVE EXTENSIVE LIAISON BETWEEN AND AMONG FIELD ENGINEERING, MANUFACTURING, AND RESEARCH.

BOX 369, ERIE, PENNSYLVANIA

FLEET ENGINEER WANTED

TVA needs a competent Fleet Engineer in its Transportation Branch located at Chattanooga, Tennessee

The salary is $5750 per year for a 40-hour workweek, with automatic within-grade increases for satisfactory service. Vacation, sick leave, hospitalization, Federal life insurance, and retirement benefits. This is diversified work including maintenance engineering, field observation, shop operations, and limited test and experimental work on automobiles, construction and marine equipment, and airplanes.

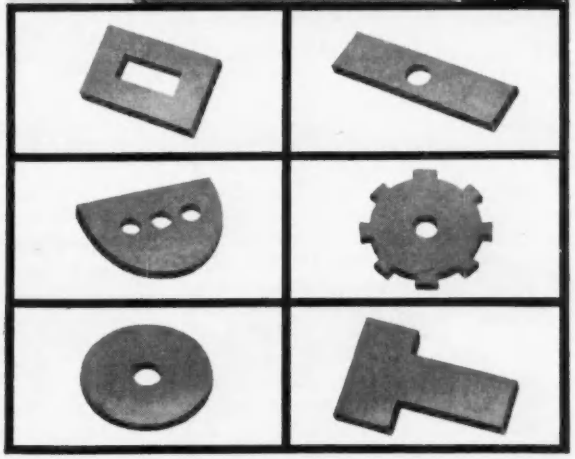
Applicants must have a bachelor's degree in Automotive Engineering, Mechanical Engineering, or Electrical Engineering; and three years of practical experience in fleet, service, or maintenance engineering.

Interested candidates should write to Tennessee Valley Authority, Examining Section, Knoxville, Tennessee.

Use sponge rubber?

U.S. Kem-Blo® SPONGE

- is a superior, light, flexible, elastic, sponge rubber.
- takes hundreds of thousands of compressions without matting down.
- can be engineered to any width, shape, thickness or compression.
- perfect for insulating, gasketing, cushioning, weather-stripping, dust-proofing, shock-absorbing, sound- and vibration-damping.



Send for our free swatch book! U. S. Kem-Blo Sponge, Dept. T-54, United States Rubber Company, Naugatuck, Conn.

US RUBBER **United States Rubber**

MAKE IT WEIGH LESS

N·A·X
HIGH-TENSILE STEEL

MAKE IT LAST LONGER

You can design light weight, longer life, and economy into your products by including N-A-X HIGH-TENSILE in your plans.

- It is 50% stronger than mild steel.
- It is considerably more resistant to corrosion.
- It has greater paint adhesion with less undercoat corrosion.
- It has high fatigue life with great toughness.
- It has greater resistance to abrasion or wear.
- It is readily and easily welded by any process.
- It polishes to a high lustre at minimum cost.

And with all these physical advantages over mild carbon steel – it can be cold formed as readily into the most difficult shaped stamping.

When you next start to redesign, get the facts on N-A-X HIGH-TENSILE. It's produced by Great Lakes Steel – long recognized specialists in flat-rolled steel products.

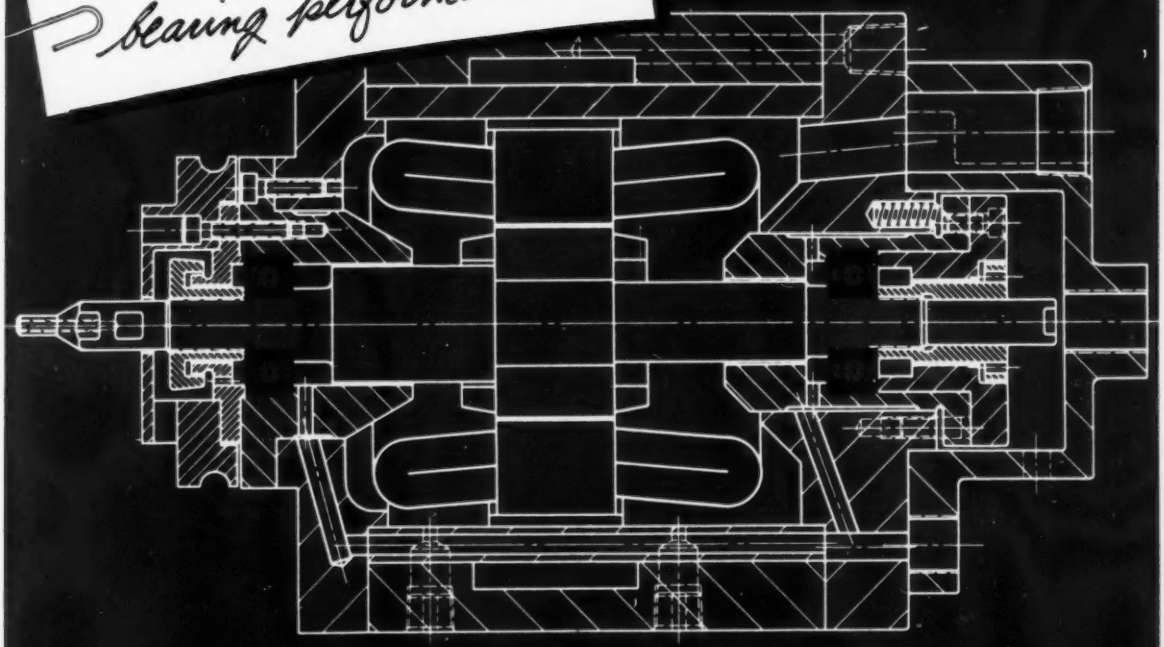
N-A-X Alloy Division

GREAT LAKES STEEL CORPORATION

Ecorse, Detroit 29, Mich. • A Unit of

NATIONAL STEEL CORPORATION

Looking for improved bearing performance?



over 14 billion revolutions...

— and still going strong

Fafnir Super-Precision MM201W1-CR spring-loaded ball bearing, the type specified for wheelhead illustrated.

Fafnir-equipped, high-speed, oscillating grinder wheelhead demonstrates machine tool progress in performance

This extraordinary record has been made on the production line by a Pope-built wheelhead, grinding the races of extra-precision ball bearings. The hi-frequency motorized wheelhead operates at 72,000 rpm. The motor is water-cooled and bearings lubricated by means of an oil-air mist system.

When designing this oscillating grinder wheelhead, Fafnir engineers worked together with the Pope Machinery Company engineers in the selection and application of bearings. The type of bearing recommended is shown at the left and its application in the drawing above. Its performance record, according to Pope, demonstrates progress to match today's improved machine tools.

Whatever your bearing problem, a few minutes spent with a Fafnir representative may be the means of solving it as successfully. Write The Fafnir Bearing Company, New Britain, Connecticut.

FAFNIR
BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

How to make your automatic heat-treating and hardening even more automatic

...at no extra cost

FAST, continuous operation is the key to profitable automatic forging production lines. Especially in high speed heat-treating and hardening operations. They're extremely sensitive to changes in chemical composition and structure of steel used. Interruptions to make tests or adjustments slow production, increase costs, reduce the advantages of automatic operation. This makes the uniformity of the steel you use an even more vital factor. The more uniform the steel, the steadier the production and the greater the potential you can realize from your automatic equipment.

You can get the utmost in uniformity, and automatic operation—at no extra cost—by using Timken® fine alloy steel. Uniformity is constant from bar to bar, heat to heat, order to order.

We take many extra quality-control steps to assure this uniformity. For example, the Timken Company uses a magnetic stirrer for molten steel to assure equal distribution of alloys, uniform temperature and improved working of the slag. It's the first installation of its type in the United States.

To further assure uniformity, your order of Timken fine alloy steel is handled individually. We target our conditioning procedures to meet your end use requirements. Each bar is stamped to identify the heat it came from. This limits variations within an order as well as from order to order. And every heat is examined spectrometrically to insure uniform grain size.

To make your automatic heat-treating and hardening operations even *more* automatic—at no extra cost—always specify Timken fine alloy steel. You'll get money-saving performance and uniform results every time. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN *Fine Alloy* STEEL

TRADE-MARK REG. U.S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING